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AUTHOR Alexander, Leigh; Simmons, John
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ABSTRACT

A number of studies are reviewed in an attempt to identify those schooling inputs that affect schooling outcomes, specifically cognitive achievement of students, in developing countries. Part 1 of the paper outlines the nature of the major tool of analysis, the educational production function (EPF), and the problems associated with its use as a policy tool. Part 2 examines how it can be used despite these problems and summarizes the findings of many studies on the U.S. educational system as a basis for comparison of findings from studies of poor countries. Part 3 critically examines nine studies completed for developing countries, and the conclusion synthesizes their findings. Two other studies using different statistical techniques are examined in the appendix. Inputs identified in all studies as having a positive impact on performance are employing highly motivated teachers, providing a minimum number of textbooks and access to general reading materials to all students, and promoting the use of homework as a teaching method. (Author/MLP)

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The Determinants of School Achievement in Developing Countries: The Educational Production Function

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March 1975

THE DETERMINANTS OF SCHOOL ACHIEVEMENT IN DEVELOPING COUNTRIES:

THE EDUCATIONAL PRODUCTION FUNCTION

Leigh Alexander & John Simmons

This paper reviews the literature on educational production functions for developing countries and suggests the policy implications. While the limitation in the estimation procedures suggest caution in interpreting the results, the results indicate that few school inputs have the effect on achievement test scores they were thought to have had. The results are consistent with studies in the developed countries.

Population and Human Resources Division
Development Economics Department
Development Policy Staff

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THE DETERMINANTS OF SCHOOL ACHIEVEMENT IN DEVELOPING COUNTRIES:

THE EDUCATIONAL PRODUCTION FUNCTION

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S U M M A R Y

This paper attempts to identify those schooling inputs which might be recommended to policymakers as having a significant impact on schooling outcomes, specifically cognitive achievement of students, in developing countries. The educational production function (EPF) is considered as an analytical tool for this purpose.

Despite problems involved in its formulation and estimation, the EPF is found to be a valid statistical technique as long as its limitations are taken into account. First, a consensus on those inputs which are effective in both developed and developing countries would lend support to the belief that the policy recommendations implied by these findings will be valid in the future. Since there are insufficient studies for the developing countries, their results must be backed up by the weight of findings from the developed countries.

Secondly, the limitations of the educational production function for economic analysis can be overcome if the results are used as the basis for sensitivity analysis of the cost effectiveness of selected educational inputs. A sensitivity analysis will ensure that the assumptions implicit in the use of the educational production function will not render the derived policy recommendations invalid if those assumptions are in fact false.

The consensus of findings from both developed and developing countries is that the student's socio-economic background is the major determinant of his academic achievement throughout all levels of schooling except the upper secondary grades. Its contribution is smaller in the developing countries than in the developed countries, while the contribution of some schooling variables to achievement is larger in the developing countries in several subjects like science. However, the impact of those schooling variables which are subject to policy control such as teacher certification and years of education, the availability of school facilities, and the composition of the student's peer group is generally insignificant except in the upper secondary grades.

On the other hand, the removal of the student from the home environment into a learning environment at school does have an important impact on his achievement. The longer he remains at school and the more he has studied the subject being tested, the higher will be his achievement. However, these exposure to learning variables are not subject to policies which alter the composition of schooling inputs. Instead they are affected by policies which expand the size of the educational system, for example, allowing students to remain in school longer, or widening their curriculum choice by teaching specific subjects at earlier grades.

Consequently, policy measures designed to improve the quality of schooling inputs entering into an educational system cannot be expected to have a large impact on the output of that system for primary and early

secondary grades. This conclusion applies only to academic subjects such as reading, science, and foreign languages since there is no evidence available for vocational school subjects.

The schooling inputs which have been examined in educational production functions for developing countries can be divided into two categories according to whether or not there is complete agreement among all studies examined in this review as to the direction of their influence on student performance. Those policies which positively influence performance in some studies, but have a negative or no influence in others include providing boarding facilities at the secondary level, using double school sessions, having larger enrollments at upper secondary grades, reducing class size or the pupil:teacher ratio, and employing teachers with more experience and qualifications and giving them tenure. Conflicting results emerge from studies in both developed and developing countries for these policies. Thus, project design should proceed largely on a local basis without relying too much on the findings for other education systems and countries.

On the other hand, there are a few inputs which have a positive impact on performance in all studies. The policies which reflect them are employing highly motivated teachers, providing a minimum number of textbooks and access to general reading materials to all students, and promoting the use of homework as a teaching method. These recommendations emerge from the results of developing country studies but they do not conflict with findings from developed countries. Consequently, policymakers in poor countries may be able to make interim decisions based on teacher motivation, textbooks, and homework without undertaking additional research, but it would be preferable to conduct prior experiments on these inputs for the educational system in question. If several future studies should show conflicting results for these variables, then they should not receive special attention from policymakers.

In summary, the findings of this review should not be seen as guidelines for policymakers, specifying for them which inputs to use and relieving them of hard decision making, but should be viewed as information which policymakers should possess before they make choices on additional research needs and policy changes.

INTRODUCTION

Efficient allocation of educational resources requires knowledge of both the costs and benefits of alternative educational processes. ^{1/} The benefits may ultimately be measured in terms of the differential lifetime earnings, physical productivity, or job promotion rates of the more educated over those of the less educated. However, an explanation of these outcomes will require an analysis of the educational process itself: identifying those worker characteristics which are rewarded by employers, and the extent to which educational resources contribute to their attainment. Furthermore, there may be benefits from more education which, although not directly rewarded in the market, are still socially desirable; for example, personal satisfaction and political change. What are the characteristics that result in these benefits, and how are they gained?

We can identify certain outputs from the schooling process, the attainment of which we would like to explain. These may include academic achievement, social competence, citizenship, responsibility, judgement, self-confidence, and creativeness. This paper is concerned with identifying the critical inputs and the importance of their contribution to school outputs. The educational production function (EPF) is one technique measuring these input-output relationships. Hence, this paper examines the explanatory power of the EPF with particular reference to less developed countries.

Part I of the paper outlines the nature of the EPF and the problems associated with its use as a policy tool. Part II examines how it can be used despite these problems; further, it summarizes the findings of many studies on the U.S. educational system as a basis for comparison of findings from studies of poor countries. Part III critically examines studies completed for developing countries, and the conclusion synthesizes their findings with the objective of identifying those education inputs which may be recommended to policymakers as being effective in improving schooling outcomes.

THE EDUCATIONAL PRODUCTION FUNCTION

The production function expresses the maximum product from an input combination at the existing state of technical knowledge. Its nature and underlying assumptions as a construct in the theory of the firm are extensively examined in the microeconomic literature; e.g., Levin, 1971a. In order to maximize output subject to a budget constraint, it is necessary

^{1/} This paper has benefitted from the criticisms of Martin Carnoy, Enrique Lerdou, Henry Levin, Herman van der Tak, and S. Venkitaramonan. They are not responsible for our omissions or commissions.

that the marginal product of the last dollar spent be the same for all inputs. The policy prescription which emerges from this condition is to estimate the marginal product of all inputs, determine their relative prices, and equate the ratios of marginal product to price over all inputs. Given this, efficiency in the educational sector would be maximized.

The most commonly used form of the EPF can be written generally as:

$$A_{it} = g(F_{1(t)}, S_{1(t)}, P_{1(t)}, O_{1(t)}, I_{it}, U)$$

The i subscript refers to the i_{th} student; the t subscript in parenthesis (t) refers to an input that is cumulative to time t , where

- A_{it} = a vector of educational outcomes for the i_{th} student at time t
- $F_{1(t)}$ = a vector of individual and family background characteristics cumulative to time t
- $S_{1(t)}$ = a vector of school inputs relevant to the i_{th} student cumulative to t
- $P_{1(t)}$ = a vector of peer or fellow student characteristics cumulative to t
- $O_{1(t)}$ = a vector of other external influences (the community, for example) relevant to the i_{th} student cumulative to t
- I_{it} = a vector of initial or innate endowments of the i_{th} student at t
- U = an error term

In terms of the schematic form of a learning system portrayed in Diagram 1, the EPF explains behavioral change in terms of both early and later factors. ^{1/} It does not attempt to quantify the links between behavioral change and the ultimate benefits of learning. The feedback loops in Diagram 1 represent the interactions between behavioral change and all other factors. The EPF can capture these effects if the model in question

^{1/} Most studies to date have not included nutritional status and general health of students among the early factors tested. Since these factors may influence both attendance and alertness at school, the studies are subject to serious weakness.

treats all educational outcomes as simultaneously determined; however, most empirical work to this time has ignored these interactions and estimated the EPF by single equation methods. 1/

Consequently, any single equation estimate of the educational production function will be subject to simultaneous equation bias. A priori, there will be feedbacks amongst the outputs of the educational system; e.g., improvements in academic achievement will improve self-confidence, or reduce the probability of dropping out. Also there will be feedbacks between any one output and its specified input vector whereby the inputs cannot all be considered to be exogenous. Thus biases will arise in the estimation of any single equation by ordinary least squares.

Therefore, the first requirement for an unbiased estimate of the EPF is that multi-stage regression techniques be used. There are additional problems which limit the accurate estimation of the EPF. Since an estimate of the marginal product of the inputs is obtained from the estimated coefficients of the EPF, these problems mean that the policy prescription of equating the ratios of marginal product to input price will not optimize educational resource allocation. In the absence of this prescription, we are in the uncertain area of the second-best and must proceed cautiously.

The first problem is the specification of the functional form of the EPF. This arises because there is no established theory of learning to serve as a guide toward either the correct mathematical form of the function, or the a priori limits on its input coefficients. In practice, additive linear functions have been most commonly used, with no restrictions on coefficient estimates.

The second problem is data limitations. 2/ They comprise:

(a) Erroneous variables: There is wide usage of dummy variables as the operational form of certain inputs. These dummies are erroneous if they fail to reflect the variance present in the input variable; e.g., "teacher characteristics" may be entered as:

1 = has a degree

0 = otherwise.

Such a variable is only a first approximation as it may miss key characteristics such as the emotional stability of the teacher. Furthermore, variables that may be important either positively or negatively may not

1/ Simultaneous equation models for the United States include Levin (1970) and Boardman, Davis, and Sanday (1973).

2/ These limitations are discussed in more detail in Keisling (1971), and Bowles (1970).

be quantified at all, for example, in-class teaching technique is generally omitted from the list of inputs. 1/ These measurement deficiencies prevent an individual production function being estimated for each student or each teacher, since the consequent aggregation of data at the school or system level may conceal the effect of the aggregated variables on individual performance.

(b) Non-longitudinal data: Cross-sectional studies can be misleading if one social class tends to move out of the school system being investigated more than other social classes. For example, countries with a significant private school system or with a low proportion of poor students in higher education may experience class movement. There may be virtually no information on the transient class if the sample includes only the remaining social classes.

Another aspect of the unavailability of longitudinal data is the difficulty of measuring the "value added" to the outputs of the school by the schooling inputs at a given grade level. For example, cognitive achievement at upper secondary school is presumed to be determined by current schooling and other inputs operating on a base of prior achievement which was in turn determined by past inputs. To measure the net contribution of current inputs to upper secondary achievement, similar achievement scores observed prior to upper secondary entrance should be held constant in the statistical analysis. In many studies this cannot be accomplished because of lack of data.

(c) Multicollinearity in input variables: The input vectors of background characteristics, school inputs and peer group characteristics all tend to be positively related to the social class of the student. Multicollinearity will vary for each EPF being estimated, and in the more recent studies it is measured. 2/

(d) Average or frontier production functions: Conceptually, the production function is a frontier of potential attainment for given input combinations. Thus, the estimation of an EPF for an individual school requires that the school be an efficient producer of educational outputs, and therefore any policy prescription using school data and based on profit maximizing premises will be misleading. In support of this statement, Levin (1971a) shows that not one condition for assuming that schools are managed efficiently is satisfied. 3/ For example:

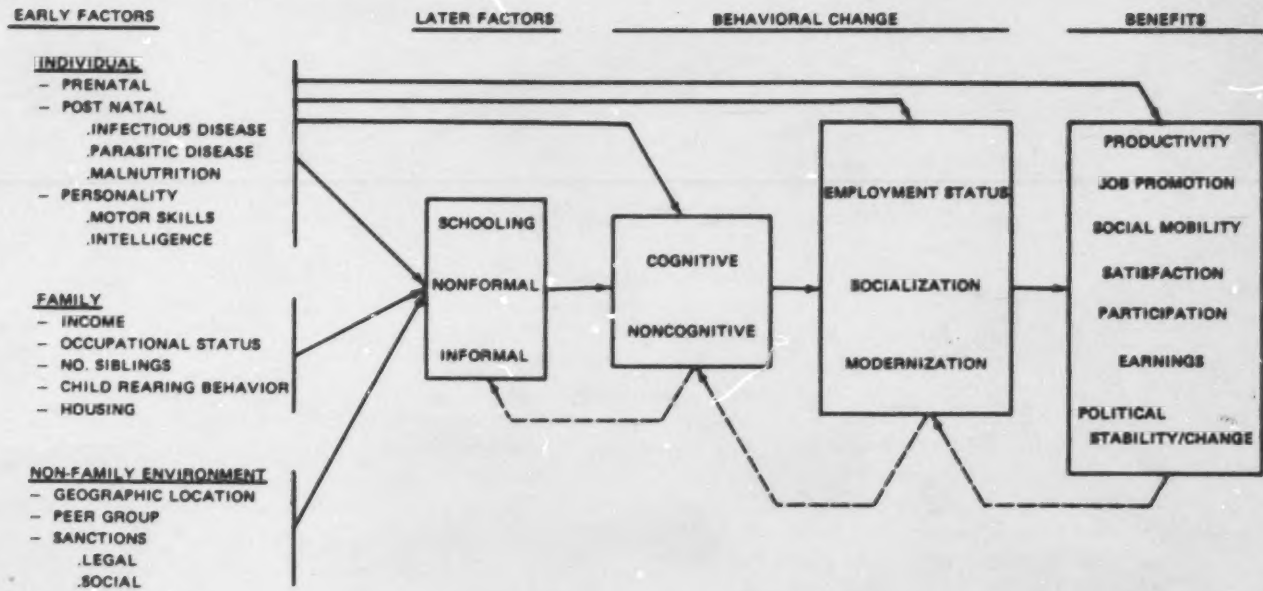
1/ See Robert Rosenthal, Pygmalion in the Classroom (1968), and Pygmalion Today (1973), Holt, Reinhart and Winston, New York.

2/ For measurement procedures, see Donald E. Farrar and Robert R. Glauber, "Multicollinearity in Regression Analysis: The Problem Revisited", Review of Economic and Statistics, February 1967.

3/ Even if direct financial incentives for educational efficiency are offered, formal schooling does not appear to be successful. See Irwin Garfinkel and Edward M. Gramlich, "A Statistical Analysis of the OED Experiment in Educational Performance Contracting," Journal of Human Resources, Summer 1970.

Diagram 1

THE LEARNING SYSTEM: CAUSES, CONSEQUENCES, AND INTERACTION



N.B. Other arrows are omitted to maintain the clarity of the diagram.
For example, Family and Non-family Environment should have dotted lines to Later Factors and Behavioral Change.

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- a. The educational managers in most schools lack knowledge of the production set for obtaining particular outcomes. Vocational training may be an exception.
- b. Substantial management discretion does not exist over which inputs are obtained and how they are organized in educational production.
- c. Little or no competition exists among schools.
- d. Prices of both inputs and outputs are not readily available to educational managers.
- e. The incentive or reward structures characteristic of schools seem to have little relation to the declared educational goals of those institutions; and,
- f. There are no clear signals of success or failure for the schools that are comparable to sales, profits, losses, rates of return, or shares of market.

A further problem is that the degree of inefficiency in educational production is likely to vary among schools. Hence, if an EPF is estimated for an entire school system, the multiple regression techniques, even if multistage, will not reproduce the efficient (frontier) technologies, but rather will yield an "average" production function. ^{1/} This means that if the marginal products from the estimated "average" EPF were used as a policy guide, an allocatively inefficient decision would be imposed on relatively more efficient and less efficient schools, possibly decreasing the allocative efficiency of the educational sector as a whole.

Only if the technical inefficiencies of schools are neutral among inputs will the educational production function be able to be used as an accurate policy guide. By neutrality we mean that at every level of inputs and for every combination of inputs, the ratios of their marginal products as estimated by the educational production function must be identical with the frontier production function's marginal product ratios, and hence be unbiased. This situation is unlikely to hold in reality.

In consequence of these deficiencies whereby the true educational production function is difficult to estimate reliably, policy recommendations based on actual estimates require caution. The textbook policy proposals derived from the theory of the firm may prove more harmful than beneficial. However, the EPF can be of practical use if its limitations are realized. This situation is examined in the next section.

^{1/} A basic assumption of least squares regression is that the errors in each equation have zero means. This implies an "average" production function. See D.J. Aigner and S.F. Chu, "On Estimating the Industry Production Function," American Economic Review, September 1968.

UTILITY OF THE EDUCATIONAL PRODUCTION FUNCTION

Despite its limitations, the production function approach does have some advantages in educational research. Multiple regression can systematically discriminate between the influences of many types of inputs using a given data set, whereas other statistical techniques must rely heavily on complex stratification of the data. Also the approach can employ comparable measures of output across many experiments. Consequently, the results of many studies can be compared, and if they are consistent, enable a description of the workings of the educational system under study to be built up.

Given a description of the educational system, but realizing the limits of the educational production function technique, the researcher should still be able to make general inferences to the policymaker regarding the direction in which expenditures on educational inputs should be allocated. However, the inadequacy of the marginal conditions for resource allocation in an educational context does prevent the researcher from unreservedly recommending the extent to which expenditures would be allocated in a given direction. Policy recommendations must be based on the information that is available, namely the coefficient estimates from the EPF. But because these estimates cannot be regarded as the true marginal products of the inputs, they must be subjected to a sensitivity analysis. This involves calculating a range of values around the EPF point estimate for those inputs that the EPF suggests have a statistically significant impact on achievement. Also this procedure should be combined with a cost-effectiveness analysis. This requires that the unit costs of each significant input be estimated, with the final result being a range of estimates of the gain in achievement per unit of expenditure for each input. The most cost-effective inputs can then be identified.

This method of arbitrarily varying the achievement per unit cost around the EPF point estimate ensures that any sensitivity of a given policy recommendation to small-scale biases in the information upon which it is based can be recognized.

In order to ensure that the direction of effect of the inputs examined in a cost-effectiveness analysis is correct, successive studies are required using valid statistical procedures to yield conclusions which reinforce each other as to the significant inputs affecting schooling outputs for a given educational system. Only evaluations of the results of statistically valid EPF studies for the United States primary and secondary education systems are reported in the following paragraphs. 1/ Examples of studies at the university level include Feldman and Newcomb (1969).

1/ This review draws heavily on the work of Keisling (1971) and Averch et. al. (1972). Both these studies summarize U.S. research.

It is useful to summarize this work before proceeding to review the EPF studies for less developed countries. This is so because few studies have been completed in poor countries, and a convergence of results of both rich and poor countries will lend greater weight to any interim research and policy recommendations for the less developed countries.

The general findings with respect to inputs explaining variance in cognitive achievement for the United States are now outlined.

1. Individual and Family Background Characteristics. Examples of individual characteristics tested include motivation, expectations, and efficacy (perceived degree of control over the environment), while family characteristics include variables such as number of siblings, socio-economic status, and information available in the home.

Here, four related results emerge:

- a. The socio-economic status of a student's family and community is consistently related to his educational outcome. (Averch, et al, p. 45)
- b. Socio-economic variables are, in most cases, more highly related to pupil performance than the most important school inputs. (Keisling, p. 20)
- c. American schools tend to improve cognitive achievement more for middle-class students compared to poorer or upper-class students. (Keisling, p. 22)
- d. The magnitude of the effects of socio-economic variables normally does not decrease as grade level increases. (Keisling, p. 23) However, this holds only up to mid-secondary grades. The contribution of home background to incremental achievement between the 9th and 11th grades is very small. (Burkhead et al, p. 53)

Hence, the strong influence of socio-economic status (SES) on student performance throughout early and middle schooling is indicated by these conclusions. There have been insufficient studies incorporating adequately measured individual student characteristics for a consensus of results for these variables to emerge.

2. School Characteristics

- a. Teacher Variables (Keisling, pp. 24-27)
 - (1) In general, neither the amount and type of college teacher training, nor whether or not teachers are formally certified are significantly related to

student performance. Also the pupil teacher ratio is generally insignificant, although some studies find it positively related to performance while others find a negative relationship.

- (11) The generally significant variables are teacher verbal ability (+) and teacher turnover (-). Also, teaching experience and teacher salary is significant but in only half the studies.

Hence, a tentative hypothesis for U.S. is that relying on teacher experience and formal certification to improve student performance is inefficient, and that a better policy would be to recruit more verbally able and intelligent teachers.

b. Physical Facilities Variables (Keisling, p. 28)

Most of the variables used to measure facilities have been dollar aggregates. However, dollar expenditures incurred over different years cannot adequately reflect both quality and quantity. The value of facilities per student and expenditure on books have been tested, and are insignificantly related to pupil performance. However, the existence of a different type of facility - science laboratories - is significantly related to performance.

c. School Administration Variables (Keisling, pp. 27-28)

- (1) Analogously to the teacher results, pay related variables (degree level and management experience of school administrators) are not related to student performance.
- (11) However, overall management resources such as the school's central administration expenditure per pupil are significantly related to performance.

In summary, it is apparent that schooling variables do not have a good track record as predictors of student scores in cognitive achievement. Unfortunately, these variables are those over which the policymaker has the most immediate control.

3. Peer Group Influences. Here the findings are even more uncertain. (Averch, et al., pp. 43-44).

- a. There is no strong evidence that the characteristics of the student's peers have an independent influence on the verbal achievement of individual students. However, there is no strong evidence to the contrary. Many alternative hypotheses can explain the data better than can peer group effects, but no one has shown that peer group effects do not exist.

- b. There is no evidence to suggest that student body effects might be negative.

Given this brief survey of EPF research findings for the United States, we now have a well-defined basic structure of results to serve as a reference point for comparison with the conclusions of poor country studies. We would expect to find strong family background effects on cognitive achievement, and possibly some significant influence of the individual's own personality characteristics. Also, these should be accompanied by a limited number of significant schooling effects on student output. Such a coincidence of findings would provide a base from which to explore possible research and policy recommendations, while keeping in mind the limitations of the EPF technique outlined previously.

EDUCATIONAL PRODUCTION FUNCTIONS FOR DEVELOPING COUNTRIES

There are at least seventeen EPF studies on poor countries available for review to this date. However, only nine will be examined in this review, and in addition, two other studies using different statistical techniques will be examined in an appendix. ^{1/} In this section the EPF studies are examined. Initially, relatively simple studies will be discussed, and then those of a more complex nature in terms of their techniques of analysis or number of variables.

1. Most studies use some measure of student academic achievement as the dependent variable in the educational production function. These will be discussed after examining one which looks at the ability of schools to retain their students - the retention rate. This study is by Levy (1971).

Sample: Cross-sectional data on primary students in 42 developing countries. The data were drawn from the Adelman and Morris (1968) study. ^{2/}

Variables:

- (1) Dependent: - the drop-out rate, defined as the ratio of dropouts to grade 1 enrollments, adjusted for repeaters.

-
- ^{1/} For a listing of all studies, see Bibliography, parts B&C. We have not been able to obtain copies of the studies excluded from this paper.
- ^{2/} Irma Adelman and Cynthia T. Morris, "An Econometric Model of Socio-Economic and Political Change in Underdeveloped Countries," American Economic Review, December 1968, pp. 1184-1218.

- (11) Independent: - the same variables as used by Adelman and Morris (A-M) plus 9 educational variables. The A-M variables comprise 19 economic indicators, 10 socio-cultural variables, and 10 political variables.

The educational variables are:

- a. Annual expenditure per pupil.
- b. Annual salary per teacher.
- c. Average annual rate of growth of enrollments.
- d. Enrollments as a proportion of school-age population.
- e. Pupil:teacher ratio.
- f. Average repetition rate.
- g. Repetition rate for grade I.
- h. Secondary enrollment as a proportion of primary completions.
- i. Level of teacher training - a combined measure of years of teacher education and percentage of qualified teachers.

Procedure: Stepwise regression using ordinary least squares, with the 48 independent variables each being entered as a rank-ordering across the 42 countries.

Results: The only significant educational variable is the average rate of repetition. The more grades the student repeated, the higher the chance of dropping out. It is positively related to the drop-out rate and is significant at the 0.01 level. Hence, it appears that schooling variables such as class size and teacher qualification do not determine the drop-out rate given these data.

However, four sociological variables are significant. Higher drop-out rates are associated with the following variables, the direction of association in parenthesis: urbanization (-); social tension (+); the

crude fertility rate (+); and modernity (+). 1/ Also two economic factors are significant: amount of physical overhead capital (-), and its rate of growth (-).

Therefore, this study indicates that the explanation of drop-out rates is mainly socio-economic, with schooling variables having very little influence. Furthermore, it points clearly to the simultaneity problems since modernity is used as an input, whereas other studies have regarded modernity as a schooling output. 2/ Ideally, both modernity, the drop-out rate, and achievement should be treated as endogenously determined outputs in the context of a simultaneous equation model.

The major drawback of the study is the aggregation at the national level. Variation of teacher and school facilities at the school and classroom level, and hence their influence on the drop-out rate tends to be diminished by such aggregation.

2. A study of simple design which uses student achievement as the educational output is that of Epstein (1970) for St. Lucia.

Sample: The author used an island-wide survey of 13-14 year-old students at both primary seventh grade and Form II secondary level to test hypotheses about the effect of parasitic disease on achievement. The sample of 162 students was stratified by capital city, other urban, and rural location and separate regressions were performed for each strata.

Variables:

(1) Dependent: - scores on the Nelson Reading Test (Grades 3 to 9).

(11) Independent: - two SES variables -- the educational level of parents, and father's occupation.

- parasitic disease - five types. 3/

1/ Although a society with a more modernized outlook would be expected to have a lower drop-out rate a priori, Levy explains this positive sign by regarding modernity as a proxy for the percentage of total first enrollment from rural areas, enrolees whose families were not committed to education.

2/ See the Holsinger (1973) study in the Appendix, & Simmons (1972).

3/ The diseases and their incidence in the sample are Bilharzia 12.7%, Hookworm 25.3%, Ascaris 51.3%, Trichura 59.5%, and Strongyloides 4.4%.

Procedure: Ordinary least squares regression with all eight independent variables represented by dummies. For example,

1 = presence of disease, 1 = high father's Occupation,
0 = otherwise, 0 = otherwise

Results: a. Both SES variables significant at the five percent level.
b. Disease not significant in explaining achievement.

The R^2 was .22 for the capital city, .18 for other urban and .16 for the rural strata.

Despite the significance of the SES variables, this study really adds little to our knowledge of the determinants of achievement within the SES group. This is because of a weak research design. The operational dummy regressors enter with equal weight, whereas in reality the variables they represent could be expected to have a differential impact on achievement. Another problem is the low R^2 - approximately 0.10 for the aggregate sample, reflecting the omission of schooling variables from the regression set. Consequently, no new information for educational policy makers is provided by this study, although its findings are consistent with other studies; i.e., the strong influence of SES on achievement at the early and middle years of schooling.

3. A more complex study examining the determinants of student achievement as measured by examination performance is by Thias and Carnoy (1969) for Kenya.

Sample: A 20 percent random sample of all primary schools in two rural counties in Kenya that presented candidates for the Kenya Preliminary Examination (KPE) in 1967, totalling 3,405 candidates. The KPE is taken at the end of seventh grade. Data were aggregated and analyzed at the level of the school, and 89 schools were included in the sample. Teacher data for these schools were obtained from the county records.

Variables:

- (1) Dependent: - average KPE score of each school.
(11) Independent: - no information on the socio-economic background of the students was available, so all regressors were schooling variables. They were:

- a. Average teacher salary.
- b. Teacher:student ratio.
- c. Average formal qualification of teachers.
- d. Average seniority (experience) of teachers.
- e. Number of students in the school.
- f. Percentage of students sitting for the KPE.
- g. Average age of KPE candidates.
- h. Percentage of students repeating the KPE.
- i. Percentage of girls among KPE candidates.

Procedure: Ordinary least squares multiple regression.

Results: There were only four significant variables, and the level of significance is shown in parenthesis.

- a. The smaller the number of students in the school, the higher the examination scores. (0.01)
- b. The smaller the percentage of KPE candidates in the student body, the higher their scores. (0.01)
- c. The younger the candidates, the higher the score. (0.01)
- d. The higher the average teacher salary, the higher the score. (0.01)

The R^2 was 0.17.

The KPE candidates production function has several important features. First, the function contains only schooling variables, but these are able to explain only 17 percent of the variance in test scores. While no measure was made of multicollinearity, it would be normal to assume that this was present among both the school variables, and between the set of school and unmeasured non-school variables. This is one source of probable inaccuracy in the estimated schooling coefficients. Secondly, the very inclusion of SES and individual personality variables could be expected to lower the estimated regression coefficients of all the significant variables so that the two at the 10 percent level would possibly become insignificant. Thirdly, the significant results for school size, candidate share, and age may in part reflect a screening of poorer quality students out of the KPE entrance lists. Consequently, these variables may be picking up the effect of the student's socio-economic background, and their significant coefficients

must be interpreted with caution. However, the significance of the teacher salary variable does not reflect student SES factors as the sample consisted of rural students who might be expected to have a lower average SES than urban students, whereas many higher salaried teachers would be more likely to have obtained urban teaching positions. In addition, the salaries of the teachers are set by the government and do not depend on the wealth of the local area to which teachers are posted.

Instead, the authors show that the importance of teacher salary does not reflect the influence of teacher qualifications, but rather underlying teacher seniority and experience. Also, it may reflect some aspects of teacher motivation, since the senior teachers who still remain in rural areas would be more reconciled to a teaching career than their equally senior colleagues teaching in urban areas with a wider range of potential job opportunities. Their younger colleagues, possibly holding higher formal qualifications, may also be less motivated toward a lifetime teaching career.

4. In the same 1969 study, Thias and Carnoy also estimate an educational production function for secondary education in Kenya at the Form IV level - the students having had four years of secondary schooling.

Sample: One hundred and fifteen schools reporting the composition of the teaching staff, expenditure on non-teacher inputs, and student performance in the Cambridge School Certificate examination for 1966. These schools were from both urban and rural areas.

Variables:

- (i) Dependent: - average examination performance in points for each school.
- (ii) Independent: - total educational expenditure per CSC student.
 - a. Number of students.
 - b. Percentage of boarders.
 - c. Average educational level of the adult population in the local district.
 - d. Number of CSC students per 1,000 persons in the local district.

Procedure: Ordinary least squares log-linear multiple regression.

Results: The significance level of the only two significant variables is in parenthesis.

- a. The larger the student body, the higher the exam score. (0.01)
- b. The more boarders in the student body, the higher the score. (0.05)

The R^2 was again 0.17.

Again, no socio-economic status variables were included in the regressions and our observations on the previous Thias-Carney study are also valid here. Possible proxies for SES are the average educational level in the local district, the examination entrance:population ratio, and the percentage of boarders. However, only the latter is significant, and this may indicate that including a direct SES variable would be preferable since the extra costs may result in only high SES students attending boarding schools. On the other hand, boarding may still have an important influence on achievement independent of home background. It results in an equal exposure to a learning environment for all students, and this may modify the influence of individual differences in home background. Also, boarding schools serve only rural students who generally are of a lower socio-economic class than urban students.

The other important result of this study is the absence of the effect of more educational expenditures per pupil on academic performance. This result conforms with the general findings of United States studies, and when taken in conjunction with the positive relationship between the number of students and examination scores implies that the number of secondary students in Kenya could be marginally increased with resulting economies of scale and no decrease of academic achievement on average. However, the direction of influence of school size conflicts with that for the previous Kenya study, showing that the determinants of achievement may vary according to the level of learning being examined.

5. Another study of academic achievement is by Simmons (1972) for Tunisia. The sample was limited in size. Two small communities were examined because the unreliability of national test scores forced the investigators to gather their own data within the constraint of a limited budget.

Sample: Rural and urban male students in the last years of primary and the first two years of secondary school were examined in 1968. The rural community was a large town of about 3,000 persons, and the overall sample consisted of 80 youths aged 13-25, with a mean of eight years of school ranging from grades 4 to 12. The sample was stratified by house type - a proxy for income. Of the 80 students, 44 were in grades 4 to 8 and these comprised the rural educational production function sample. The urban community was a low- to middle-income suburb of Tunis, and 88 students in grades 4 to 8 were chosen, stratified on a similar basis.

Variables:

- (i) Dependent: - scholastic achievement as indicated by scores on multiple choice tests in Arabic, French and arithmetic.
- (ii) Independent: - approximately 130 variables were tested, grouped into the following subsets:

School Type: primary, secondary, technical, apprenticeship, pre-primary, or tutoring.

Student Performance: grades repeated, change of school.

Family Background: housing type, parents' education and income, parents' home reading and media use, education supervision at home, urban exposure, and religiosity. These were also combined into a SES index.

Student Personality: experience, aspirations, modernity, and need achievement. 1/

Schooling input variables such as teacher quality and class size were deliberately not tested since it was assumed that, on the basis of prior studies, they would have little effect. While this is a weakness of the study, it was unavoidable because of the inconsistency of the national examination scores and budget constraint.

Procedure: Stepwise least squares regression on individual blocks of independent variables, and on all 130 variables together. The criterion for rejection of a variable was a level of significance greater than .05.

Results for the Rural Sample:

- (i) French Achievement - The significant variables and their significance level emerging from the combined regression on all variables were:

- a. attendance at secondary school (.01),
- b. sibling's influence (.01)(-),
- c. the SES index (.05),

and d. student experience in school clubs (.01)(-).

The overall R^2 was .59, and multicollinearity was low. 2/

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- 1/ Measurement procedures for these variables were originated by Inkeles and McClelland. See Simmons (1972) for discussion.
 - 2/ Low multicollinearity was indicated by testing the determinant of the X'X matrix as suggested in Farrar and Glauber, op. cit.

Both the time a student had been exposed to learning French at the secondary level and his SES were positively related to French achievement. However, the more influence siblings had on him, and the more he participated in organizations such as political clubs, the lower would be his French score, on average.

(ii) Arabic Achievement - The significant variables did not include years of secondary schooling or the SES index. However, some parental and student background characteristics were significant. They were all positively related to achievement, unless otherwise indicated. The variables were:

- a. urban birthplace (.10), 1/
- b. urban visits of the mother (.05),
- c. father's occupation as a farmer (.10) (-),
- d. amount of noise during homework (.05),
- e. student's best friend is a relative (.10),
- and f. student's exposure to TV (.10).

The overall R^2 was .60.

Hence, some aspects of the home background were important in the learning of the native language. 2/ For example, urban contact had a positive influence, whilst the physical hardships farm children face in getting to school seems to have impaired their performance. It is unusual that apparent distractions from memorising homework such as background noise may in fact have aided the retention of subject matter.

In summary, the strong effect of home environment at primary and early secondary grades on achievement is consistent with the findings of the U.S. studies. Schooling after the primary level has little effect on learning in subjects to which the student is exposed at home, such as the native language. However, it may be important in other subjects such as a foreign language.

1/ Although the significance level is greater than the rejection criterion of .05, this and other .10 variables were significant at the criterion level when regressing achievement on an individual block of background, schooling or personality variables. Regressing all blocks together raised their significance level to .10.

2/ The test was of standard Arabic used in the schools and not the Arabic used in the vernacular.

Results for the Urban Sample:

(1) French Achievement - The significant variables in the complete regression were found to be:

- a. attendance at a secondary school (.10),
- b. parents' education (.01),
- c. household per capita income (.05),
- d. father's radio listening habits (.05) (-),
- e. student's use of French outside school (.05),
- and f. well-lighted homework conditions (.01).

The total R^2 was .41.

These results are similar to those of the rural sample as the exposure to learning a foreign language at school is an effective predictor of good test scores. However, an examination of the various significance levels reveals that the home background factors of both parents and students are more important determinants of achievement than exposure to learning. Of special interest is the importance of good homework conditions, since both the amount of homework and physical lighting conditions could be relatively easily changed by government policy.

(11) Arabic Achievement - A similar pattern of significant home background and exposure to learning variables occurred. They were:

- a. mother's education (.01) (-),
- b. father's salary (.05),
- c. household income per capita (.05),
- and d. attendance at a primary school (.01).

The inverse relationship of mother's education to achievement contrasts sharply with the direction of influence of parental educational status in all other studies. There is no apparent reason for this result. Generally, the results of the rural sample are repeated in that schooling in the native language beyond primary school added little to cognitive skills in that language.

(111) Arithmetic Achievement - In contrast to the results for language achievement where personality variables such as modernity and need achievement were never significant, modernity was an important predictor of arithmetic achievement for urban students. The significant variables were:

- a. modernity (.05),
- b. father's radio listening habits (.05) (-),
- c. father's movie going habits (.05),
- and d. number of grades repeated at school (.01) (-).

The overall R^2 was .28.

Again, exposure to learning has little positive effect on achievement, and moreover, repeated failure at school can have a disincentive effect on learning.

In summary, this study indicates that the findings of U.S. research regarding the importance of schooling inputs are confirmed. It does not add any evidence to the question of the effectiveness of many of the inputs which can be directly policy controlled, such as class size, teacher qualifications, or schooling expenditures. However, it does suggest that homework, especially the physical conditions of home study, can have a significant effect on achievement. Furthermore, since only primary schooling was important for Arabic achievement, and secondary schooling for French achievement, only limited effects from exposure to learning at school can be expected, depending on the material being studied.

The strong effect of background factors from the student's home and environment suggested by U.S. studies is also borne out. In the study of certain subjects, such as the native language, background factors play a dominant determining role, whilst for other subjects, their influence is modified as schooling variables increase in importance. However, they never fail to have an important effect on learning for those students in late primary/early secondary grades.

6. Probably the most sophisticated study to this date is Carnoy and Thias (1974). It also examines the Tunisian education system and employs a simultaneous equations model, although only the reduced form results are reported. In addition, it is able to directly measure the contribution of secondary schooling to achievement independently of achievement in primary school. Finally, it attempts to measure the effects of individual teacher - student interactions in the classroom. It is a large scale study financed by the I.B.R.D. based on data collected in June 1969.

Sample: The final sample consisted of 6,195 secondary students of both sexes in rural and urban areas of Tunisia. These students attended the schools which were chosen on a non-random basis according to:

- (i) their location in Tunis or in other areas,
- (ii) their offering of a lower secondary or a complete secondary cycle, i.e. grades 7 through 11, and

- (iii) their curriculum type: technical or general.

Within each school, grade 11 was over-sampled, as were students taking less popular subjects. Within classes either each student or every second student (alphabetically) was included in the sample.

Variables:

- (i) Dependent: - Seven dependent variables were tested, mainly
- a. current year grade point average (GPA),
 - b. change in GPA between years,
 - c. number of grade repetitions,
 - d. preference for French over Arabic as a language,
 - e. student self-esteem,
 - f. job expectations, and
 - g. modernity.
- (ii) Independent: - about 80 variables were tested, comprising three major blocks. These were:
- a. Home background variables, such as parental occupation and education, articles and reading material in the home, and number of siblings. These were also combined into a index of SES.
 - b. Pupil characteristics, such as attitudes toward peers, subject preferences, teacher preferences, distance travelled to school, whether boarding at school and entrance level GPA.
 - c. Teacher characteristics such as nationality, sex, qualifications, experience, whether under contract, attitudes toward students, and lesson preparation.

Schooling characteristics such as class size, teacher:student ratio and expenditure per pupil were not included in the regressors because of the small number of schools included under the sampling design. Instead the study was designed to measure individual characteristics of teachers and students and the effect of their classroom interaction on learning. Hence, teacher characteristics were not averaged over schools, but were paired with individual student characteristic observations. This constitutes an improvement in the design of this study over that of most others. Also, the achievement "value added" by secondary school was measured since the students' grade point average at their secondary entrance examination was included among the independent variables tested.

Procedure: The variables finally tested were chosen by firstly eliminating from consideration others receiving a high non-response or an obviously inaccurate response during interview. Then a factor analysis on the remaining variables was used to identify 16 clusters of determining variables and of these, variables with a low factor loading were eliminated. Then the remaining 80 variables were subjected to a separate stepwise regression on each block of variables using the equivalent of a 0.10 level of significance as a rejection criterion.

Results: Of all the dependent variables, only current year GPA was reasonably well explained by the independent variables, that is, the proportion of total variance accounted for was reasonably large. For this variable, the maximum R^2 was .30 for 8th year students and the minimum R^2 was .19 for 11th year students.

For this reason, and for brevity, the discussion will be limited to current GPA only.

Pupil characteristics beyond the control of the secondary school accounted for most of this explained variance. However, their explanatory power diminished as pupils moved to higher grades. This was mainly because of the smaller explanatory power of the entrance examination score at the beginning of secondary school in these higher grades. ^{1/} In the higher grades, teacher characteristics within the control of the school system accounted for an increasing proportion of explained variance, outweighing the effects of the external pupil characteristics. Hence, by measuring individual teacher-student interactions in the classroom, the study indicates that some policy controlled variables can have a significant effect on achievement, at least at the upper secondary level.

The variables found to be consistently significant across most grades of secondary school at a .10 level of significance at most were: ^{2/}

- a. GPA at entrance exam (+),
- b. Years repeated at primary school (-),
- c. The student's liking for school and degree of work in comparison to his peers (+).
- d. The student's ability to follow written directions (-).
- e. Whether the student boarded at school (+).

^{1/} The smaller influence of entrance GPA was not due to students of lesser ability dropping out in higher grades since the mean entrance GPA of the remaining students declined, and the variance remained constant. Increasing severity of grading is one explanation for the decline in the mean score.

^{2/} Significant levels were not reported.

The significant teacher variables, and the grades in which they were significant were:

- a. Male teacher (+), (.10) grade 8; (-), (.10) grades 10 and 11. ^{1/}
- b. Holding a teaching contract (-), (.01) grades 9 and 11.
- c. Years of experience (-), (.01) grades 9 and 11.
- d. Qualifications (-), (.10) grade 10.
- e. Authoritarian attitude (+), (.10) grade 9.
- f.
- f. For a Tunisified teaching force (-), (.05) grade 11; and (+), (.10) grade 10.

These findings indicate that the higher the teacher qualifications and the more they are experienced, the lower the achievement scores at upper secondary levels. This can possibly be explained by senior teachers being less motivated to perform well, given that they had performed acceptably in the past. This is borne out by the negative impact of holding a teaching contract which provides job security. However, this result must await confirmation from other studies of upper secondary achievement.

A result somewhat consistent with the Kenya study is the lack of significance of teacher experience in early lower secondary grades. However, the lack of effect of teacher qualifications at this level is consistent with the Kenyan findings. The observed efficacy of authoritarian teaching methods is a surprising result for democratic educators; however, it too must await further confirmation.

The other policy controlled variable that was significant was whether the student boarded at his secondary school. The size of the boarding coefficient estimate increased between year 7 and 8 from almost zero to 0.8 and stayed constant until year 11 when it halved. This bears out the results of the authors' Kenya study, where boarding was the most important variable explaining grade 11 examination scores. Also, it does not conflict with the Simmons (1972) study, since boarding was not included as a regressor. In fact, it is consistent with the negative impact on achievement of living on a farm and its alternative demands on a student's time indicated by the latter study.

^{1/} The teacher sex variables really reflect the effects of all-boys and all-girls schools at different years, i.e., an intra-school effect. However, no allowances were made for possible differences in the ease of grading.

However, there is one problem in making a policy recommendation to increase boarding facilities on the basis of this evidence. This is that socio-economic status was generally found not to be significant in determining GPA. Only in the 8th year was it important. It is possible that boarding is a proxy for SES and that it picks up most of the effects of home background, since only the relatively well-off can afford to send their sons to boarding school. Scholarship aid is insufficient for all who would qualify. Thus, it may not follow that providing boarding facilities for low SES students would significantly improve their academic achievement.

On the other hand, it is more likely that boarding is a valid policy variable for similar reasons to those indicated in the Kenya study. There, boarding schools are located only in rural areas serving the lower socio-economic classes. Also it may indicate a broader hypothesis, namely that the important schooling variables are those which increase the student's exposure to learning and to the schooling environment, even to the point of living there full time.

The lack of significance of the student's home background at the first year of secondary school contrasts strongly to the results of the Simmons study for Tunisia, which concentrated on the last year of primary and the first two years of secondary school. However, the lack of influence of SES for secondary grades 9 to 11 is a new result and leads to the hypothesis that the impact of home background diminishes throughout the upper secondary grades after largely determining student performance throughout primary and the first two years of secondary school. From then on, schooling variables have an increasing impact.

This can be explained by both the screening out of lower SES students from higher grades which reduces the variance of the SES variables in the regression, and by the cumulative effect of the student's exposure to a schooling environment. The early influence of home background is reflected in the significant effect of entrance-level GPA throughout all grades, and the effects of boarding and teacher inputs which are greatest in middle secondary and higher grades.

A recent study is that of Schiefelbein and Farrell (1973) for Chilean primary and early secondary schools employs another statistical technique in addition to multiple regression analysis.

Sample: The authors studied a nationwide random cluster sample of eighth grade classes stratified by location in a primary or secondary school. The response was 353 out of 479 classes with 10 students per class being selected at random. The response rate from these students and their teachers was high. The survey was conducted by questionnaire in 1970.

Variables:

- (i) Dependent: - achievement scores on the national 8th grade test. It consisted of 100 questions, half verbal and half mathematical.
- (ii) Exogenous: - a set of student and family background characteristics.
- (iii) Instrumental: - sets of teacher, schooling and peer group characteristics. 1/

The authors did not provide a complete listing of all variables used, and reported only the significant variables.

Procedure: Ordinary least squares multiple regression.

Results: Significant variables in explaining variance in cognitive achievement are given below with the significance level in parenthesis, followed by the Beta coefficient.

From exogenous variables:

- (i) Hours spent per week in free reading (.05), .153;
- (ii) SES factor score - a complex weighting of indices of the following variables based on factor analysis (.05), .096:
 - a. education of student's parents,
 - b. educational aspirations of the student,
 - c. family consumption,
 - d. father's occupational status, and
 - e. number of contacts made by the family with "educated model" figures, e.g., teachers, artists.
- (iii) average liking for academic subjects (.05), .069; and
- (iv) student height - indicating a high probability of malnutrition (.10), .036.

From instrument variables:

(i) Teacher variables:

- a. average age of teachers (.05), .067;

1/ A complete listing of variables was not reported, however they included teacher qualifications, class size, and number of school sessions per day.

- b. average SES of teachers (defined similarly to that of students) (.10), .039.

(ii) School variables:

- a. textbook availability (.05), .063;
- b. school size factor score (.10), .033. 1/

(iii) Peer Group variables:

- a. average eighth grade score of the student's class (.05), .183;
- b. homogeneity of the class in terms of achievement (.05), .168; 2/ and
- c. average possession of a T.V. set in the home per class (.05), .119.

The overall R^2 was 0.26.

These results largely support the conclusions for the developed countries and the previous developing country studies although there are some important differences. The academic qualification and training of the teacher is again not significant, however inherited teacher socio-economic status is somewhat important. Of more importance, as indicated by its Beta coefficient is teacher age and implicit experience, and this conforms to the results of some U.S. studies as well as to the Kenya study.

The strong combined influence of parental socio-economic status and the individual's expectations is evidenced again, although by referring to the relatively low size of the SES Beta coefficient, the authors argue that home background is not as strong a predictor of academic achievement for Chile as it is for the U.S.. However, there is the problem of probable multicollinearity among the regressors, especially between SES, possession of a T.V., and textbook availability. The zero-order correlations between these variables are all about +0.6, and far greater than the simple correlations between any other pairs of variables. Consequently, if these correlations in fact indicate high multicollinearity 3/ the estimated regression coefficients of these variables will suffer from loss of precision.

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- 1/ School size factor score is a composite of total enrollment, average class size, and teaching costs per student. As such, it provides no policy guide, as the independent influence of each component cannot be identified.
 - 2/ Homogeneity is represented by the reciprocal of the standard deviation of class scores.
 - 2/ It would be preferable to test directly for multicollinearity. See Farrar and Glauber, op. cit.

Thus, the high Beta coefficient for T.V. possession may simply be, to a large degree a reflection of the impact of SES on achievement. Hence, there may be greater similarity between U.S. and Chilean results than the authors allow.

The authors observe that the multicollinearity problem exists, but argue that it can be overcome by the use of "commonality analysis." ^{1/} This indicates that the unique contribution of the block of student background characteristics to the explained variance of the regression is only 15%, or less than half of the contribution of the peer group variables. However, T.V. possession is included in the peer group block and not in the home background block. Therefore, this analysis cannot lend support to the accuracy of the reported coefficients for SES and T.V. possession.

A similar uncertainty applies to the coefficient of textbook availability, as it too may partly reflect the influence of SES on achievement depending on the extent to which parents supply the texts. However, to the extent that the coefficient is accurate, it represents an important departure from U.S. results. Support for a significant effect of this variable on achievement, independently of social class, is shown in that the difference in mean test scores between students with few and many textbooks is nearly identical for students with high education and low education fathers. Also, students with few textbooks in private schools (where the impact of textbook availability is greatest) are by no means exclusively lower class, as 40 percent of these students had highly educated fathers. Thus, Chilean 8th grade achievement appears to be affected by whether or not a student has access to textbooks. Since absolute income differences are greater in Chile than in the United States, there would be greater variance in textbook ownership in Chile which would be picked up in the regression. ^{2/} This result may reflect the absence of a policy to provide textbooks to all students, as 11 percent of the sample had no textbooks in five subject areas. However, the result also has far wider implications. It points to the possible existence of threshold levels of school inputs for developing countries. Schooling variables may in fact make significant contributions to cognitive achievement up to these levels, but make little contribution after these levels have been achieved.

The greatest difference between the U.S. and Chilean results is the significance of the two peer group variables. The magnitude of their effect is shown firstly by the size of their Beta coefficients which are the largest of all the coefficients, and secondly by commonality analysis. This indicates that uniquely, they explain more of the explained variance than background characteristics or schooling variables. Combining this effect with the unique effects of schooling variables, almost one-third of

^{1/} Commonality analysis partitions the R^2 into the unique effect of each set of variables and the joint effect of each possible combination of variable sets.

^{2/} The textbook variable was entered as a mathematically scaled score, not as a simple dummy; 0 or 1.

the explained variance is accounted for. It is important that both peer group and schooling variables could be manipulated by policy-makers. For example, the peer group effect indicates that "tracking" may improve achievement in Chilean schools, and also points to the importance of measuring the influence of learning conditions within the classroom in future research.

Peer-group effects were also important in the preceding study (Carnoy-Thias, 1974, see above 6). The student's degree of work in relation to his peers was a strong prediction of his GPA.

8. Another statistically advanced study is by Carnoy (1971a) for Puerto Rico. At that time it was unique amongst developing country studies in that it tested and reported on a simultaneous equations model of schooling outputs.

Sample: A 1967 survey of 182,000 Puerto Rican students in grades 1 through 12 of public schools was taken, however only the data for grades 3, 6, 9, and 12 were used in order to reduce computation costs. The sample was stratified into urban/rural and male/female students and the individual responses were averaged for each grade and school. Data on the teacher of the students in the sample were obtained from the files of the Department of Education. The variables were all measured as school averages, but the exact number of the units of observation - schools - was not given. The variables' subtitles are in parenthesis.

Variables:

(i) Endogenous:

- a. Achievement of students in each school in a Spanish reading examination. (SPREAD)
- b. Achievement of students in each school in a general ability test. (GENAB)
- c. Level of schooling that students expect to obtain. (EXPECT) This is considered a proxy for motivation.
- d. Adjusted self-estimate of students in the school. (ADJUST) This was calculated as the individual self-esteem score/individual SPREAD score.
- e. Degree of student's wish to transfer from the school currently attended. (TRANSF)

(ii) Exogenous: Non-school variables:

- a. Index of father's educational and occupational status (AVGSOC). This is a measure of family background characteristics.

- b. Degree of parents' discussion of homework with students. (PARCON)

School variables:

- a. Daily number of hours students attend their school. (ENRHRS)
- b. Age of students in the school. (AGESTU)
- c. Class size. (CLASIZ)
- d. Academic preparation of students' teachers. (ACPREP)
- e. Teaching experience of teachers. (EXPER)
- f. Percentage of certified teachers. (CERTIF)
- g. Percentage of teachers on permanent contract. (CONTYP)
- h. Percentage of male teachers. (SEXTEA)

Procedure: Given a simultaneous equations model, both the structural form and reduced form were estimated. The structural form sets each endogenous variable as a function of all the other variables in the model i.e.

- (1) $SPREAD = f (TRANSF, EXPECT, ADJUST; X_1)$ where $X_1 =$
exogenous variables
- (2) $TRANSF = f (TRANSF, EXPECT, ADJUST; X_1)$
- (3) $EXPECT = f (TRANSF, SPREAD, ADJUST; X_1)$
- (4) $ADJUST = f (TRANSF, SPREAD, EXPECT; X_1)$

The estimation of equations (1) - (4) was by two stage least squares.

The reduced form sets each of the endogenous variables above as a function only of the exogenous variables of the equation. These reduced form equations were mathematically derived from (1) - (4) above, and estimated by single equation least squares regression. GENAB was also included as a dependent variable in the reduced form.

The model was estimated separately for each grade, sector (urban/rural) and sex of students.

Results:

(i) Reduced Form. Given the large number of equations estimated, each significant regressor will not be specified. Instead, a summary of results with respect to variables significant at the 0.10 level will be more informative. The discussion will be limited to the regressions of Spanish reading achievement on the exogenous variables in order that the findings may be comparable with other studies' results.

A result which supports the findings of the Kenya, Tunisia and Chile studies is that some of the teacher characteristic variables are significant for the same grades. This occurs with a direct SES measure included among the regressors, and therefore the results carry more weight than the Thias-Carnoy Kenya findings. Teacher experience is positively related to student performance in reading achievement in the third grade but has an inverse relationship in the 9th and 12th grades. Teacher certification is also negatively related to student performance in the 12th grade, as is teacher academic preparation in both 9th and 12th grades.

However, some of the findings for teacher characteristics oppose those of previous studies. (a) The percentage of teachers on permanent contract is positively related to performance in both 9th and 12th grades. The author suggests that the combined effect of teacher certification and contract is also positive, and this conflicts with his findings for Tunisia. (b) Teacher academic preparation is positively related to performance throughout primary school, and suggests that primary teachers will perform better if they complete their secondary education. (c) Male teachers have a negative influence on achievement throughout grades 5 to 9. This also conflicts with the author's Tunisia study where male teachers had a positive influence in the 8th grade.

The results for the schooling variables also both support and oppose those of previous studies. The number of hours a student attends school is positively related to performance in rural 3rd and 6th grade schools. This result is not comparable to U.S. findings as the variance in U.S. hours of attendance is much smaller, however it indirectly supports the hypothesis suggested by the Kenya and Tunisia studies that the length of exposure to a schooling environment has an important impact on achievement.

In contrast, the current study finds that increasing the class size has a significantly negative impact on school performance in the 6th and 9th grades. This applies especially to lower SES students in urban schools where average class size is larger than in rural schools. This result is in sharp contrast to the findings of all the previous LDC studies.

The role of family and home background factors is similar to that in the U.S. and the previous LDC studies. The relationship between the SES index and/or parental conversation with student examination performance

is always positive and generally significant throughout all grades except the 12th. This is additional evidence of the diminishing effect of SES in upper secondary grades. Moreover, the explanatory power of the independent variables in the reduced form equation is better for higher than lower grades. The R^2 is around 0.6 for grades 9 to 12, and around 0.3 for grade 3. This reflects the cumulative influence of the teacher and schooling variables whereby students have an increasing exposure to the schooling environment, rather than the increasing influence of home background factors.

(ii) Structural form. Again, only a summary of results will be presented. The most important general result was that the inclusion of the other three endogenous variables (EXPECT, ADJEST, and TRANSF) in the equation explaining Spanish reading achievement markedly reduced the effect of SES and increased the effect of the school inputs. In some cases, the coefficients of father's educational and occupational status became insignificant, whilst those of teacher experience and academic preparation were greatly increased in size. However, only for 3rd grade students did these teacher variables become significant with a positive relationship to student performance. This is consistent with the results of the reduced form regressions.

Other than this effect, the structural form estimation adds little new information to the reduced form results. In addition, this finding must be treated with caution because of the high multicollinearity among the endogenous variables.

The main reason that the structural form parameters convey no additional information is that with this particular data set, there are very few significant relationships between the endogenous variables themselves. These links are necessary for the potential advantages of structural form estimation to be realized. A multi-stage regression will pick up the indirect influence of the exogenous variables on a particular endogenous variable operating via the other endogenous variables. However, the following diagram shows that only the student's self-esteem significantly affects Spanish reading achievement, and then only for the 3rd grade rural students.

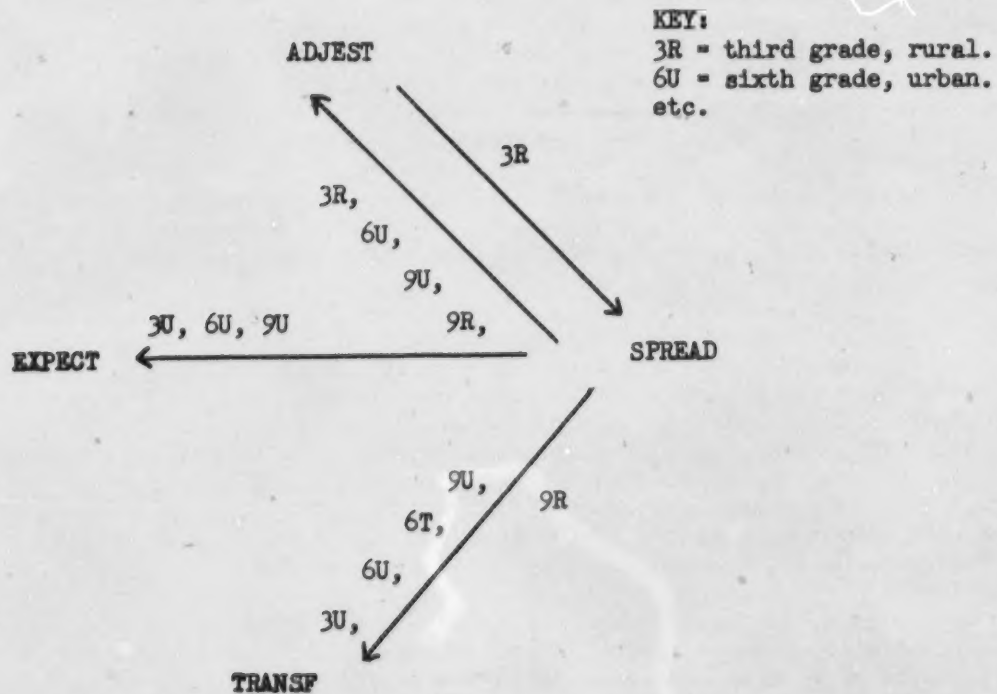
A possible reason for these limited gains from the structural form estimation is that the unit of observation was the school and therefore the interactions among the endogenous variables taking place in the classroom (where we might expect them to be highest) were averaged out. Consequently, we should not conclude that there is no additional value attached to a properly specified simultaneous equation model where the unit of observation is the individual student.

9. An important study which goes beyond an educational production function to also include a cost-effectiveness analysis is that of Beebout (1972). Also, it incorporates a quasi-longitudinal measure of school performance as the dependent variable.

Diagram 2

Significant Relationships between Endogenous Variables

(10% level). Carnoy-Puerto Rico



Sample: A proportional random sample of 89 schools was drawn from all secondary schools in West Malaysia that had a full upper secondary level (Forms IV and V) in 1969. The sample was stratified by language of instruction (Malay or English) and by state. Data were obtained from questionnaires to school headmasters, audits of individual school accounts, and results on standardized national examinations. Examination scores were matched for 7,674 students in the selected schools.

Variables:

(i) Dependent: - achievement of individual students at the upper secondary level as measured by an index of the student's performance relative to that of his peers. Performance was indicated by the difference between entrance examination and completion examination scores at this level.

(ii) Independent: - potentially important sets of variables not included in the analysis were direct measures of the student's socio-economic background, such as parental occupation and education. However, indicators of SES were available in the out-of-school inputs reported below. The variables included were:

Student Background - Student scores on a national secondary entrance examination.

Outside-the-School Educational Inputs -

Percentage of non-Malay students.

Percentage of students from agrarian family backgrounds.

Location near an urban center.

Boarding school or not.

School Inputs -

Percentage of qualified teachers.

Average years of teacher experience.

Teaching material expenditure per student.

Class size.

Teacher motivation.

More than 10 percent untrained teachers.

Use of audio-visual aids.

Percentage of library use.

Quality of library materials.

Building age.

Conditioning Factors which modify school inputs -

Girls' school, boys' school or coed.

Double or single session school.

Size of school.

Percentage of students in science stream.

Except for the entrance examination score, the unit of observation of all variables was the school and not the individual student or subject area. Hence, the design of the study prevents any influence of individual student-teacher interactions being measured. However, it does allow the achievement "value added" by upper secondary schooling to be measured since it holds constant the accumulated impact of background and schooling factors prior to upper secondary school by including secondary entrance examination score among the regressors.

Procedure: A quadratic functional form was first estimated by ordinary least squares multiple regression. It was chosen after an extensive analysis of the desirable economic and educational properties implicit in alternative theoretical forms of the production function. Probable interactions between variables were identified by a stepwise analysis of variance prior to estimation.

Results: Using the significance criterion of $F_{1.5}$, that is, a significance level of approximately 0.80, none of the non-linear terms were significant over the range of data tested. Hence the quadratic form was dropped, and a multiplicative interaction term for teacher qualifications and teacher experience was included in a linear regression.

From this regression, the significant variables, their significance level and direction of influence were:

Table 1: Significant Variables of Beebout-Study

<u>Variable</u>	Malay <u>Language</u> $R^2 = .56$	English <u>Language</u> $R^2 = .65$
entrance examination score	0.01 +	0.01 +
agrarian family background	0.01 +	
urban fringe location	0.01 -	
teacher qualification	0.01 +	
teacher experience	0.01 +	0.01 +
interaction term	0.01 -	0.05 -
untrained teachers	0.01 -	0.01 -
class size	0.01 -	
teacher motivation	0.10 +	
library use	0.01 +	0.01 +
building age		0.05 -
girls' school	0.05 +	0.01 +
coed school		0.01 +
double session	0.01 -	
school size	0.01 -	
science major /1	0.01 -	0.01 +

/1 The difference in sign between the two school types reflects the de-emphasis of science in Malay schools. The best students were encouraged to take liberal arts.

The variables that were not significant at the .10 level were

<u>Malay language</u>	<u>English language</u>
Non-Malay ethnic	Boarding school
Boarding school	Agrarian family background
Audio visual use	Audio visual use
Teaching material expenditure	Teaching material expenditure
Quality of library	Quality of library
	Teacher motivation

Of the significant variables, the entrance exam score was by far the most powerful, accounting for 47 percent of total variance in achievement for Malay schools and 60 percent for English schools. This is consistent with U.S. data and indicates that it is unlikely that students can markedly change their relative achievement levels during upper secondary school. This variable probably reflects in part the accumulated influence of socio-economic background through primary and early secondary grades. This applies especially to English language instruction. The lack of effect of out-of-school variables for English schools bears this out.

In contrast, home background factors still have some additional effect at the upper secondary level in Malay schools. The positive influence of agrarian background reflects the parental occupation of most students at those schools, while the urban fringe dwellers are of the lowest socio-economic level, and this adversely affects their school performance. This indicates that an agrarian background need not be a handicap in upper secondary grades, and that policy should instead be directed at prior home or school influences on achievement while the student is in lower grades.

The lack of influence of boarding on achievement contrasts strongly with the results of studies in Kenya and Tunisia. Also contrasting with other studies the exception being Puerto Rico, is the negative influence of higher class size within the range 24 to 46 students on achievement, although the size of its influence was negligible. These results indicate that caution may be required in applying results of a given study to other countries.

Furthermore, there is disagreement with the previous studies over the teacher inputs which influence achievement at the upper secondary level. Teacher qualification and teacher experience have a significantly positive, rather than negative impact, independently of student SES. ^{1/} However, these variables were not associated with large gains in achievement. The interaction term indicates that as the level of one teacher trait rises, the marginal product of the other falls. Hence, in schools with largely inexperienced

^{1/} The author argues that the observed low correlation between entrance examination score and percentage of qualified teachers indicates that the teacher effects are not due to qualified teachers migrating to schools with higher SES students.

staff, increasing the number of highly qualified teachers can markedly increase student achievement. But if the staff is of average experience, achievement gains will be small.

The percentage of untrained teachers was, however, associated with much lower scores, and library usage also increased achievement substantially. Building age did not have a consistent effect across both types of schools.

Of the conditioning variables, only student sex had a consistent impact on achievement. The better performance of females reinforces U.S. and other studies, for example, the Carnoy-Thias study for Tunisia.

Given these results, the author then performed the next stage of analysis required in order to make policy decisions, namely, determining which of selected variables with a significant influence on achievement were the most cost effective to implement. The "marginal achievement product" per dollar of input cost for different variables is shown in the following table: ^{1/}

Table 2

ESTIMATED GAINS IN ACHIEVEMENT PERCENTAGE POINTS PER UNIT OF EXPENDITURE

<u>Input Variable</u>	<u>Malay Medium</u>	<u>English Medium</u>
Percent qualified teachers	.010	---
Untrained teachers	.083	.144
Years' teaching experience	-.142	.011
Class size	.028	---
Boarding school	---	.0006
Double sessions	.077	---

Source: Beebout, "The Production Surface for Academic Achievement," p. 197.

^{1/} The use of the estimated regression coefficients as marginal products is based on assumptions that the specified production function is correct and complete, that technical efficiency in schooling production has been achieved, and that the resultant estimate is of the frontier production function. No sensitivity analysis was undertaken, and its omission is a weakness of the study.

This table shows that the most effective way of improving student achievement is to reduce the number of untrained teachers. Next would be changing Malay instruction from double to single sessions and then reducing class size. Although the regression coefficient for teacher experience is positive, its interaction with teacher qualification is negative. Varying qualifications while holding experience at its mean causes the cost effectiveness ratio to become negative.

There are many assumptions regarding input costs required to perform this analysis, but it does indicate the next step in the decision process. Its significance is that optimal policy decisions can only be made with the help of detailed analysis of input costs as well as input influence on achievement.

By far the largest study completed to this date is that of the International Association for the Evaluation of Education and Achievement (IEA) - a seven-year study in 23 countries examining student achievement in six subjects. These were science, reading comprehension, literature, French as a foreign language, English as a foreign language, and civil education. Only science and reading achievement will be examined here. Science is reported in Comber and Keeves (1973) and reading in Thorndike (1973).

Sample: The data covers three populations in each of the countries participating in the study. The population definitions are:

Population I - all students in full-time schooling aged 10 years at the time of testing. It was intended that these students would be in primary school and taught by a general class teacher.

Population II - all students in full-time schooling aged 14 years. These students should be in secondary school just prior to the end of the period of compulsory schooling.

Population IV - all students in the terminal year in full-time secondary education programs.

Population III was not under international definition. It was chosen by each country as somewhere between populations II and IV.

The country participation in science is shown in Table 3, with the less developed countries included being Chile, India, Iran, and Thailand.

Three stage stratified probability samples were drawn with stage I selecting administrative areas, stage II selecting schools, and stage III choosing students. The aim was to keep the number of students selected from each school at about 30 and to include as many schools as possible, depending on resource availability. In India, the sample was limited to Hindi speaking states.

Table 3
Country Participation in the IEA Science Study

	Australia	Belgium (Fl)	Belgium (Fr)	Chile	England	FRG	Finland	France	Hungary	India	Iran	Italy	Japan	Netherlands	New Zealand	Scotland	Sweden	Thailand	United States
Population I	—	x	x	x	x	x	x	x	—	x	x	x	x	x	—	x	x	x	x
Population II	x	x	x	x	x	x	x	x	—	x	x	x	x	x	x	x	x	x	x
Population IV	x	x	x	x	x	x	x	x	x	x	x	x	—	x	x	x	x	x	x

x indicates participation.

Source: Comber and Keeves, p.12.

Overall, up to 258,000 students and 50,000 teachers in 9,700 schools were involved in the study.

Variables

(i) Dependent: - "science achievement" as a whole, including earth, biological and physical sciences. A core curriculum, common to the science education of all countries was identified, although there were exceptions for each country. Earth sciences were underrepresented in some developed countries, while biology was underrepresented in India and Thailand but overrepresented in Iran. All four LDC's had a heavy concentration on physics. Given the core curriculum, tests of this material were constructed by an international panel in a multiple choice format for each population. Each country agreed that the tests were a reasonable general measure of science as taught at the particular level. The scores on these tests then became the dependent variable.

(ii) Independent: - there were postulated some 500 independent variables describing the students' home background, their prior and current schooling, the teachers and teaching methods, the school organization, and some student expectations and attitudes. Hence, every effort was made to identify the determinants of achievement.

Procedure: Stepwise linear regression within each of four blocks of variables to determine those contributing to a reduction in the unexplained variance of science test scores. The blocks were as follows:

- (i) Student
 - a. Home background of student.
 - b. Sex, age of student.
- (ii) Type of school and/or program.
- (iii) Learning conditions at school, covering schooling, teacher, and student variables.
- (iv) Kindred variables, i.e. expected occupation, education, attitudes, and interests.

Variables with an F score exceeding 2.00 were allowed to remain in the regression, hence some variables with non-statistically significant scores may well have been included as final regressors. ^{1/} The 'Student' scores are not reported; however, the standardized partial regression coefficients of some of the variables from the final regression are reported and for lack of guidance we assume that they are statistically significant at the usual .05 or .10 levels.

Results:

POPULATION I. The surviving variables explaining variance of science test scores are shown below. Those consistently related across countries to science achievement in terms of the sign of their standardized partial correlation coefficients are asterisked, and their positive or negative relationship is indicated in parenthesis.

^{1/} This procedure was designed to identify those variables consistently appearing across many countries with coefficients of the same sign. It was preferred to identifying only a few significant variables for each country, however, its value for policy purposes is questionable. It is essential that informed decisions be based on analysis where the results are believed, with a given degree of confidence, not to be owing to chance.

Table 4

Determinants of Science Achievement for 10 year-olds

<i>Block 1: Home and Student Background</i>		
* Home circumstances (a composite variable)	(+)	<u>1/</u>
Age of student		
* Sex of student	(-)	<u>2/</u>
<i>Block 2: Type of School</i>		
<i>Block 3: Learning Conditions in the School</i>		
Total enrollment		
Coeducation at Population I		
Pupil teacher ratio		
Percentage male teachers		
Sex of teacher		
* Opportunity to learn	(+)	<u>3/</u>
* Grade	(+)	
Class size		
* Hours homework per week	(+)	<u>4/</u>
* Regular Science lessons	(+)	
* Science textbook available	(+)	
* Observations and experiments	(+)	
Design own experiments		
<i>Block 4: Kindred Variables</i>		
* Like school	(+)	
* School motivation	(+)	
Parents help with homework		
* Hours TV watched per day	(-)	
* Hours reading for pleasure	(+)	

1/ The home circumstances variable is a composite of father's occupation, father's education, mother's education, use of dictionary, number of books in the home, and family size.

2/ The (-) sign indicates a poorer performance by girls compared to boys across nearly all countries.

3/ "Opportunity to learn" indicates the proportion of students in each country who had been previously exposed to all the test material. The variable is the school average score rather than an individual student's score.

4/ For all schooling and teacher inputs, the individual student is represented by his school's average score.

It should be noted that of the Block 3 variables, some directly subject to policy control are not consistently related to achievement. These include enrollments, pupil:teacher ratio, and class size. The instrumental policy variables that are consistently related to achievement are hours of homework, use of observations and experiments, and textbook availability, all indicating that certain teaching methods may have a positive impact on achievement. The exposure of a student to a schooling environment also has a positive influence on his achievement, as is evidenced by the other variables of Block 3 consistently related to achievement, namely opportunity to learn, grade, and regular science lessons.

Some indication of the magnitude of effect of the variables is shown by the contribution of the different blocks to the explanation of total variance of science scores. Student sex explained 2 percent of the variance on average, but only half this amount in the developing countries. Their kindred variables explain more than the average 6 percent of variance, with the Chilean figure at 12 percent. However, these variables are not directly influenced by educational policies.

The mean contribution of home circumstances is 8 percent, but this figure is much smaller for the developing countries - 2 percent in Chile, 4 percent in Iran, and 0 percent in India. ^{1/} Since possible biases because of multicollinearity were explicitly recognized in this study, this result directly supports the assertion of a relatively smaller role of home background factors in the Schiefelbein and Farrell Chilean study. It is an important finding since it allows a relatively greater role of schooling variables at primary grades in the developing countries. In fact, this seems to be the case since learning conditions had a higher than the 8 percent average explanatory power in the LDC's, even up to 20 percent in India. However, whether this is due to the policy controlled variables, or to the remaining exposure to learning variables of Block 3 is an important question. The latter variables are not subject to marginal policy changes but are "all or nothing" variables, that is, a student either goes to school or he does not. They imply no policy recommendations to improve the achievement of those students already in school.

The answer can be inferred from an examination of those significant standardized regression coefficients reported in the study. The level of significance is not indicated.

Table 5
R²'s AND STANDARDIZED COEFFICIENTS OF SCIENCE SCORE ON
SELECTED LEARNING CONDITIONS VARIABLES (BLOCK 3).

<u>Country</u> /a	<u>Partial R²</u> <u>Block 3</u>	<u>Total</u> <u>R²</u>	<u>Population I</u> <u>Exposure to Science</u> <u>Variables</u>			<u>Policy Controlled</u> <u>Variables</u>		
			<u>Opp.</u>	<u>Regular</u>		<u>Home-</u>	<u>Text-</u>	
			<u>Learn</u>	<u>Grade</u>	<u>Lessons</u>	<u>Work</u>	<u>book</u>	<u>Obs.&Exp.</u>
Chile	.09	.26		0.17	0.11			0.06
India	.20	.29	0.22	0.16	0.12		0.17	-0.05
Iran	.06	.32		0.14	-0.06	0.03	0.05	0.12

/a Results for Thailand were not reported because of multicollinearity in the regressions.

It is evident that the coefficients of the exposure to science variables are much larger than those of the policy variables. Only textbook availability in India is of equivalent magnitude. This difference in effect strongly indicates that the contribution of the Learning Conditions block to the variance of science achievement overestimates the potential effects of variables directly subject to policy control within this block. Although this block's partial R²'s are significant proportions of the total R²'s, the effect of policies which improve teaching methods and aids will not be large.

POPULATION II. The surviving variables of the regression, and those consistent in sign across many countries are shown below. The figures in parenthesis in block 4 are the weights used in forming the composite variables. Consistent variables not in Population I have their sign in parenthesis.

Again, the teaching methods variables are consistent. Also, motivation and qualification of teachers appears to be important since subject association membership and the employment of parttime teachers are consistent in their effects across all countries.

Home circumstances in the developing countries again explain less of the total variance of test scores than in the developed countries. The overall average is 10 percent, but only 2 percent in India, 3 percent in Iran and 9 percent in Chile and Thailand is explained by them. Also, student sex in the LDC's explained less than the average across all countries of 4 percent.

Table 6

Determinants of Science Achievement for 14 year-olds

Block 1: Home and Student Background

- * Home circumstances (a composite variable)
- Age of student
- * Sex of student

Block 2: Type of School or Course

Type of program
Type of school

Block 3: Learning Conditions in the School (Selected variables only)

- Total enrollment
- Percentage Science teachers
- * Sex of teacher (-)
- * Teacher subject association membership (+)
- * Part of time employed (-)
- * Opportunity to learn
- * Grade
- * Hours homework per week
- * Total years' study of Science (+)
- * Currently taking Science (+)

Block 4: Kindred Variables

- * Like school
- * School motivation
- * Science interests and attitudes (a composite variable)(+)
- Science interests and activities (3)
- Science in the world scale (2)
- Importance of Mathematics (1)
- * Expected education (+)
- * Hours reading for pleasure (+)
- * Science reading (a composite variable) (+)
- Reading Science and technical books (1)
- Reading Science fiction (1)
- Reading Science articles in newspapers (1)
- Viewing Science TV programs (1)

Learning conditions again explained a larger proportion of the variance in the LDC's test scores, with the figure for Thailand being 23 percent. In contrast to Population I, the explanatory power of the kindred variables of the developing countries was less than the average of 5 percent.

The important learning conditions variables can again be inferred from those standardized regression coefficients reported in the study.

Table 7

R²'s AND STANDARDIZED COEFFICIENTS OF SCIENCE SCORE ON SELECTED LEARNING

CONDITIONS VARIABLES (BLOCK 3), POPULATION II

Country	R ² , Block 3	Partial R ²	Total R ²	Exposure to Science Variables			Policy Controlled Variables		
				Grade	Taking Yrs.Sc. Science	Study	Home-work	Teacher Sex	Subj. Assn. Membership
Chile	.06	.25	0.95	0.14				-0.11	0.07
India	.08	.24	0.20	0.14	0.04		0.06		0.04
Iran	.09	.17	0.12	0.07			0.08	-0.05	0.20
Thailand	.23	.37	0.29	0.10	0.11		0.09	-0.05	

Similar results to those for Population I are shown in that the policy variables have a much smaller impact than the exposure to science variables. On average, the exposure coefficients are half as large again as the policy coefficients. Thus, learning in science does take place as the student progresses through the schooling system and is more exposed to the subject. Some additional learning is owing to policy variables such as better teachers and teaching methods, but they cannot be relied upon to produce large improvements in science achievement at the primary and mid-secondary grades.

POPULATION IV. The surviving variables of the regression and those consistent in sign are similar to those of the other populations. Additional consistent variables at level IV were the amount of post-secondary schooling received by science teachers, hours spent preparing lessons, and total school enrollment. Both are positively related to science achievement. The latter variable suggests that in upper secondary grades, smaller schools may lack the facilities and staff for effective science teaching.

The variance analysis reveals that home circumstances make a much smaller contribution to achievement on average (2 percent) at this level. Learning conditions now explain more variance than before - an average of 17 percent, and student sex is still important - an average of 11 percent

explained. The mean contribution of the kindred variables remains the same at 5 percent. However, there is a wide range in the explanatory power of learning conditions (Block 3) for the developing countries. This is shown in the partial R^2 's of the following table which also compares the regression coefficients of the "exposure" and "policy" variables.

Table 8
 R^2 's AND STANDARDIZED COEFFICIENTS OF SCIENCE SCORE ON
SELECTED LEARNING CONDITIONS VARIABLE (BLOCK 3), Pop. IV

<u>Country</u> ^{/a}	<u>Partial R^2</u> <u>Block 3</u>	<u>Total R^2</u>	<u>Exposure to Science</u> <u>Variables</u>			<u>Policy Controlled</u> <u>Variables</u>	
			<u>Grade</u>	<u>Study</u>	<u>& Homework</u>	<u>School</u> <u>Enroll-</u>	<u>Teachers'</u> <u>Tertiary</u> <u>Schooling</u>
Chile	.08	.32	0.08		0.09	0.23	
India	.17	.26	0.03	0.07	0.19		0.04
Iran	.04	.11		0.06		0.09	0.14

^{/a} Results for Thailand were not reported because of multicollinearity in the regressors.

The variable "current science study time and homework" is a composite of exposure and policy variables, hence, no information on the importance of homework as a teaching method can be gained for level IV. The influence of grade differences has diminished by the time students have reached population IV, and the effect of the policies designed to improve school facilities and teachers motivation and training are much stronger. However, the exposure to science learning variables still have important impact on achievement.

Summary

Because of design deficiencies in this study, care must be taken when interpreting the findings if the influence of policy controlled variables on achievement is to be determined. These variables are combined with the exposure to learning variables in Block 3, and the study reports only the contribution of the whole block to the explanation of variance in science scores. Since this block has an important influence on achievement at all levels of schooling, the impression that educational policies have strong effects might be gained. However, a closer analysis of the few regression coefficients that are reported reveals that the important variables in Block

3 are those representing exposure to learning. This is an important finding in itself and is further evidence in support of the hypothesis emerging from the Kenya and Tunisia studies that the length of exposure to a schooling environment has a positive influence on achievement. However, the key finding is that policy controlled variables do have an effect, but that it is weak at the primary and lower secondary grades, and only becomes stronger at the upper secondary level.

The findings of nearly all of the previous studies are also supported in that student socio-economic background variables and student sex are important determinants of science achievement at all levels of schooling, but there is now additional direct evidence that their influence is smaller than in the developed countries. In conjunction with this result, the effect of schooling variables is relatively stronger in the developing countries, but as stated above, this is mainly because the student is exposed to a learning environment at school. Both results reflect the far greater contrast between the average home and schooling environments in the developing countries. The average home environment in developing countries provides little opportunity for learning the material taught in school, whereas learning of school material in developed countries is more of a continuous process at both home and school.

The previous finding that the effect of socio-economic background diminishes at higher levels of schooling is also shown in this study. Possible explanations for this are (a) the stronger accumulated influence of exposure to learning, (b) enrollments being more selective with students from more homogeneous backgrounds remaining in the system, and (c) a greater requirement for student ability, with less able students having previously dropped out. This assures some correlation between SES and ability.

The other block of variables examined in this study was the kindred variables block. At all levels of schooling, student attitudes, home interests, and educational and job expectations are only marginally important determinants of science achievement.

The policy controlled variables that are important include textbook availability at primary grades, the amount of homework completed (although this may reflect student motivation) and teacher motivation - as reflected in their membership of subject associations, curriculum reform panels, and the amount of time spent in lesson preparation. The positive influence of textbook availability bears out an important finding of the Schiefelbein and Farrell study. Teaching techniques concentrating on student observation and self-experimentation are effective at the primary level, and teacher qualification as shown by the absence of parttime staff and the amount of post-secondary teacher schooling is effective at the upper secondary level. This latter finding contrasts with those of the Carnoy studies in Tunisia and Puerto Rico but supports that of Beebout in Malaysia. Teacher and student sex is also important. Male teachers have a positive effect on male students in primary and lower secondary grades. This result conflicts with that of

Carnoy in Puerto Rico, but conforms to that of at least two other studies. Hence, policies to give female students greater access to female teachers may well be worthwhile.

The average amount of variance in test scores explained by all the independent variables increased over each grade level. However, the amount of explained variance in the developing countries was generally less than average at the secondary levels. The exact figures are reported below.

Table 9

TOTAL R²'s FOR THE DEVELOPING COUNTRIES

<u>Population</u>	<u>Average All Countries</u>	<u>Chile</u>	<u>India</u>	<u>Iran</u>	<u>Thailand</u>
I	.27	.26	.29	.32	
II	.36	.25	.24	.17	.37
IV	.44	.32	.26	.11	

This result may be due to measurement error in the variables or the existence of non-linear relationships between test scores and independent variables. Alternatively it may be due to a differential impact of omitted variables between developed and developing countries at the secondary level. The variables omitted from this study include student ability, motivation, and affective characteristics, and it is probable that only the highly able and motivated students can overcome adverse home conditions in less developed countries, and remain in secondary education. These traits would then be important attributes of secondary students in LDC's and their omission would greatly reduce the proportion of variance explained by the remaining regressors.

This does not imply that the basic determinants of learning differ across countries. The repeated consistency in sign across all countries for the three populations of the same variables reported above bears this out and there is substantial agreement for the findings of this study with those of the other studies for less developed countries.

Finally, the IEA study of reading comprehension in the native language across sixteen countries is examined. Those countries participating in the science study but omitted from reading comprehension were Australia, France, Ireland, Japan, Poland, Rumania and Thailand. The results are reported in Thorndike (1973).

Sample

The same three populations as in the science study were examined for this study.

Variables

- (i) Dependent: - the score on an objective test of reading comprehension designed for each population. The tests contained 40 items with considerable overlap of questions between each population level.
- (ii) Independent: - the same 500 variables were considered as in the science study, except that the variables describing the students' home background were aggregated into four composite variables. These composites, and their constituent parts, with weights in parenthesis, were:
 - a. Socio-economic status:
 - father's occupation (0.25)
 - father's education (0.06)
 - mother's education (0.12)
 - b. Availability of reading materials in the student's home:
 - use of dictionary (1)
 - number of books at home (4)
 - number of magazines received (1)
 - presence of a newspaper (1)
 - c. Parental interest in the child's education:
 - expressed interest (2)
 - encouragement to read (1)
 - d. Parental help with homework:
 - correction of speaking (1)
 - correction of written matter (1)

Procedure: A stepwise regression using the same criterion for the retention of variables as in the science study was employed.

Results

POPULATION I. Of the 24 percent of variance in reading scores explained on average by the final regressors, socio-economic status, student sex, and availability of reading materials in the home contributed over half

(14 percent). Their contribution in the developing countries was much less than average, around 1.5 percent in both Chile and India, and 8.7 percent in Iran.

Learning conditions in the school only explained 4 percent and this was almost entirely accounted for by the exposure to learning variable - Grade. Policy controlled variables had little effect across all countries, the most consistent variable in sign being the presence of a library or book corner in the classroom. The report does not state if this variable was statistically significant, however this result supports Beebout's finding that library usage is positively related to achievement.

The kindred variables describing the students' characteristics contributed rather less in the developing countries. Learning conditions again explained only about 4 percent of total variance and Grade accounted for half of this. The only consistent policy variable in the developing countries was hours of homework per week and it accounted for just 0.6 percent of reading score variance.

POPULATION II. Home conditions contributed about the same percentage for 14-year-old as for 10-year-old students on average, and again they contributed rather less in the developing countries. Learning conditions again explained only about 4 percent of total variance and Grade accounted for half of this. The only consistent policy variable was hours of homework per week and it accounted for just 0.6 percent of reading score variance.

The kindred variables had slightly more explanatory power than in Population I, with the significant variables for developing countries being the students' preference for reading, hours of reading for pleasure, parental interest and help in school work, and frequency of movie attendance. The latter two variables were negatively related to reading achievement.

POPULATION IV. As in the science study, the contribution of home conditions diminished at this grade level to about half that of the lower grades. The amount of variance accounted for by learning conditions was marginally greater than in lower grades, and the only significant policy variables showing a consistent direction of influence were hours of homework per week and the proportion of native tongue teachers who were female. A positive influence of female teachers on female students at upper secondary grades was also indicated in the Carnoy (Tunisia) and Beebout (Malaysia) studies. However, the amount of total variance accounted for by these policy variables was minimal. Also, it should be noted that the amount of post-secondary schooling of teachers was not significantly related to reading achievement for population IV as it was for science achievement.

The contribution of the kindred variables was smaller than for prior grades, with significant variables being parental correction of speech and writing (negative effect) and students' preference for reading (positive effect).

Summary

The influence of the home environment as evidenced by both parental SES and student attitudes and preferences is effective in producing students who perform well on tests of reading comprehension, especially at primary and mid-secondary grades. The policy controlled schooling variables have a much smaller influence on reading achievement than they do on science achievement which in itself was extremely limited. The only variable significant for secondary grade levels in influencing achievement is the amount of homework students undertake per week. This bears out the finding of the Simmons and Askoy study that the determinants of achievement vary according to the subject under consideration.

Hence, the results of this study suggest that educational policy changes operating on the school system will have little impact on student reading achievement since their effects will be vastly outweighed by the prior experiences derived from home environment and family background the student brings with him to school. However, there is one caveat to this rather dismal conclusion as some schooling variables were omitted from the study. It was not designed to reflect teacher-student interaction in the classroom, since the teacher and school facilities data were averaged for each school. The inclusion of variables such as teacher expectations of student achievement in a properly specified simultaneous equation model may well indicate a potentially greater role for educational policy changes. ^{1/} For example, the Carnoy-Thias study of Tunisia attempted to allow for these interactions within a reduced form model and found a significant but negative contribution of teacher experience and qualifications at the upper secondary level.

CONCLUSION

We have reviewed the literature on the educational production function. While it is a valid statistical technique for studying the internal efficiency of educational systems, its limitations must be recognized. For example, the implications of production function studies based on the theory of the firm will cause misleading policy recommendations if applied without modification to education systems. The ratios of marginal products to input prices cannot be blindly equated.

A degree of judgement is required to determine the reliability of the coefficient estimates from the EPF as indicators of the true marginal products of the inputs. Of importance here is the correspondence between the population from which the sample was drawn and the population to which policy

^{1/} See Boardman, Davis and Sanday (1973).

decisions are to be applied. Even so, it will almost certainly be impossible to assume that the functional form of the EPF is correct, and that the schools of the system in question are efficient producers of school outputs. Furthermore, in many cases it will be impossible to identify the "value added" to cognitive achievement at a given level of schooling because an estimate of student cognitive achievement prior to entry to that level is unavailable.

However, it may be that the measurement of value added is less important at the primary level since schooling variables have had little or no influence on cognitive achievement prior to primary school entrance. Also, learning accomplished at home prior to primary entrance is likely to be highly correlated with parental socio-economic status. Therefore, as long as SES is held constant in the regression, the gross effect of schooling variables on achievement at the primary level may approximate the net effect. At the upper secondary level, measuring achievement value added may be more important. This is attempted in the Carnoy-Thias and Beebout studies but not in the others which cover the higher grade levels. Nevertheless, there are no consistent differences between the results of the Tunisia and Malaysia studies versus the Kenya, Puerto Rico and IEA studies which might indicate that the latter were seriously deficient because of their failure to measure value added. Thus, a study's failure to allow for value added may not be a serious limitation to its usefulness.

To minimize the effect of this and the other limitations of the EPF, a sensitivity analysis of the cost effectiveness of the inputs is required, explicitly stating the costing assumptions, and considering the marginal products separately and in combination to determine the most effective use of available resources.

This review also shows that there is a general consensus of results of various EPF studies for developed countries, particularly the United States, and that the studies for developing countries have not yielded conclusions too different from this consensus. Schooling inputs do have an effect on academic achievement, although for many school related variables tested, it is either weak or statistically insignificant. Furthermore, the impact of any significant policy controlled schooling variables will almost certainly be very small in relation to the other determinants of student performance such as home background and individual personality. Despite this, an objective of this review is to identify those schooling variables which the weight of evidence might recommend as the basis for interim policy decisions in the developing countries. This will be done in the following summary. However, the relative importance of home background and schooling variables will be discussed first, and then the schooling inputs themselves will be examined. Our conclusions are summarized in Annex Table 1.

There is a strong effect of home background or parental socio-economic status on student performance at primary and lower secondary grades in all academic subjects tested. (There is no evidence for vocational school subjects.) However, in these grades, home background accounts for less of the

variation in performance in the developing countries than in the developed countries. This is suggested in the Schiefelbein-Farrell study and is shown conclusively in the IEA studies.

One explanation for this is that there is a much smaller range of home background conditions in the developing countries since few homes provide an environment conducive to the learning and retention of academic material. Another explanation is that the role of schooling variables is more important in the developing countries than in the developed countries. In some subjects, for example general science and foreign language study, the impact of schooling variables as a whole may be greater than that of home background. But for other subjects such as the native language, schooling variables have a smaller impact. These conclusions are evidenced in the Simmons and IEA studies.

In interpreting the impact of schooling variables on achievement in developing countries, it is necessary to distinguish between "exposure to learning" variables and "policy controlled" variables. The majority of the effect of schooling variables as a whole is due to the exposure to learning subset. These variables are not subject to policies affecting resource allocation in an education system of a given size, nor to policies affecting the quality of schooling received. Instead, they are subject to policies which change the size of the education system by determining whether or not a student obtains more schooling: for example, the student's grade level, his length of study of a given subject, and his current study of the tested subject are all exposure to learning variables. For evidence of the relative roles of policy and exposure variables, the reader should refer to the tables describing IEA science.

Hence, schools in developing countries do promote learning, but the average rate of learning of primary and early secondary students is not markedly affected by educational policy changes along traditional lines, such as providing more and/or better teachers and facilities. Learning occurs mainly through a student being removed from his home environment and being exposed to a learning environment at school. The exact mechanism of this transmission of knowledge is unclear.

Furthermore, nothing conclusive can be stated about the relative importance of the student's peer group in promoting achievement. It is found to be more important than home background in the Schiefelbein-Farrell study, but there is reason to believe that this result may be spurious because of an improper grouping of variables. Most other studies are not designed to provide evidence on this question.

Another finding is that the role of home background factors diminishes as the student proceeds through the secondary cycle. Eventually, policy controlled schooling variables have a greater influence on achievement in the upper secondary grades. For example, in the IEA study of terminal

secondary science achievement, the average contribution of home background across developed and developing countries is 2 percent while that of all schooling variables is 17 percent. Of this 17 percent, policy and exposure to learning variables explain about equal amounts. Separate examination of the developing countries reveals a similar pattern of influence, and the other studies which covered upper secondary achievement also bear this out. The only study which indicates a strong role for home background at higher grade levels is Beebout for Malaysia, and then only for Malay language instruction schools. Reasons for the declining influence of home background and the increasing impact of schooling variables over the student's career are that schooling variables appear to have a cumulative impact on achievement, and that many low socio-economic status students have been screened out of upper grade levels resulting in a more homogeneous distribution of SES among the remaining students.

Returning to the impact of the policy controlled schooling variables on achievement, there is sufficient inconsistency within the results of the studies examined in this review to prevent more than a few variables being recommended as a possible basis for interim policy decisions aimed at improving educational efficiency. An interim decision is one taken on the basis of previous findings without the benefit of additional research on the system to which the decision is to be applied.

One policy controlled variable which also increases the student's exposure to a learning environment, and might therefore be expected to have a significantly positive effect on his performance, is the provision of boarding facilities at the secondary school. The two Carnoy-Thias studies in Kenya and Tunisia support this assertion, but it is opposed by Beebout in Malaysia. This means that the extension of boarding facilities cannot be recommended for all developing countries without pilot studies being undertaken. Nevertheless, boarding should be regarded as a variable with high potential to improve student performance. ^{1/}

This same conclusion must be applied to the other instrumental policy variables which have had a positive influence on performance in some studies, but a negative or no influence in others. One of these variables is the use of double sessions at primary and early secondary grades to extend formal education to more students. Schiefelbein-Farrell find that double sessions have a positive influence on achievement whereas Beebout finds the opposite.

Larger school size at the upper secondary level was found to be important by both Thias-Carnoy and IEA, possibly because larger schools have the required teaching aids and school facilities. However, Beebout again found a larger enrollment to be detrimental to performance, perhaps because smaller schools have superior facilities in Malaysia.

^{1/} Planners should also ask if there are ways to provide the learning conditions provided by boarding schools without incurring their expense.

A traditionally important variable for the internal efficiency of schooling as argued by educators is class size or the pupil:teacher ratio within the range 25 to 45 students. The larger the class size or higher the pupil:teacher ratio, the lower the student achievement. Five studies, including both IEA studies, found this assertion to be incorrect. However, Carnoy in Puerto Rico and Beebout in Malaysia found that a larger class size did in fact have a negative impact on performance. Neither of these countries were in the IEA sample.

There is also lack of agreement among the studies with respect to the influence of teacher characteristics on student performance. Again, no general policy recommendations for these variables can be made. But each of the following conclusions is lent support by a larger number of studies than oppose it, so at least an indication of the direction of consensus is available. The conclusions are:

(i) Teacher certification and academic qualification are not important at primary and lower secondary grades. However, they appear to be important at upper secondary grades, given the agreement across developed and developing countries in the IEA science study of the significance of post secondary schooling of teachers.

(ii) The percentage of teachers on permanent contract (tenure) is not important at primary and lower secondary grades. However, it may have a positive or a negative influence in upper secondary grades depending on the country being examined. This agnostic conclusion is evidenced by the IEA science study and the Carnoy-Thias study respectively.

(iii) Teacher experience does have a positive influence on performance in primary and lower secondary grades. However, it is not important in the upper secondary grades.

(iv) Teacher sex has a changing impact on performance. Male teachers positively influence male students from grades 5 to 8, but have a negative influence on male and female students at the upper secondary level. However, the negative influence of male teachers is evident in Puerto Rico by the 8th grade. At higher grade levels, female teachers positively influence female student performance.

Finally, there are the few instrumental policy variables which are consistently significant in the same direction of influence in all studies in which they are tested. These variables should receive the greatest attention from policymakers interested in making interim decisions without undertaking additional research. The studies indicate that:

(1) Gross expenditure variables such as cost of school facilities per student or average teacher salary are not important predictors of student performance. Thus, unit costs could be significantly lowered without affecting performance.

(ii) Teacher motivation as indicated by the actions of teachers, for example, the time spent in lesson preparation and membership of curriculum reform committees, is positively related to performance. Beebout comes to the opposite conclusion, but his variable reflects the opinions of headmasters about their teachers' motivation and not the actions of the teachers themselves. Policy should therefore be directed toward identifying highly motivated teachers.

(iii) Textbook availability at the primary level is an important predictor of performance in developing countries. An associated variable is the availability and use of a library at primary and early secondary grades. The policy implications include supplying a minimum number of texts or reading materials to all students.

(iv) The amount of homework performed by students, the physical conditions of home study, and the amount of reading performed at home are important predictors of student school achievement. All these variables indicate that the more a student can be exposed to a learning environment in the home, the higher will be his achievement level. Their policy implications are to ensure that teacher training courses promote the use of homework as a teaching method, and that students are at least provided with adequate conditions for home study and free reading. General reading material, in addition to textbooks could also be made available to students.

Thus, the only variables that might be recommended to improve internal efficiency of education systems in developing countries without undertaking additional research concern teacher motivation, textbooks and other reading materials, and homework. Specific recommendations on the basis of other teacher characteristics, school facilities, and composition of the student peer-group, must be based on research on the system in question. However, it should be noted that if just one future study were to find that teacher motivation, homework or textbook provision were negatively related to or had no influence on achievement, then these variables would no longer fall into a special category. Consequently, it is also preferable to conduct prior research on these variables before making policy decisions concerning them.

In closing, there are some recommendations arising from this review as to the methods by which this research should be carried out. In contrast to most of the reviewed studies, future educational production functions should examine all schooling outputs rather than analyze one in isolation. Variables such as academic achievement, the drop-out rate, modernity, motivation and self-esteem should be treated as simultaneously determined outputs. Two stage least squares should be a preferred statistical procedure, especially as the functional form of the equations in the system, other than the one being estimated, does not have to be specified. Also, further interaction with other disciplines must be made for a substantive improvement in results to emerge. Refining the measures for

academic motivation and other schooling outputs is possibly the first step in this process. 1/ Finally, value added by a particular level of schooling should be measured where possible.

These recommendations should provide a sound basis for sensitivity analysis of the cost-effectiveness of the inputs suggested by EPF research, which is a necessary condition for valid policy recommendations.

1/ A study which attempts to define a measure of academic motivation for 11th grade Puerto Rican students is Farquhar and Christensen (1968). Its aim is to determine the influence of child rearing and other psychological-sociological factors on motivation and thence on academic achievement. Some psychologically interpretable instruments are suggested.

Annex Table 1

RESULTS OF EDUCATIONAL PRODUCTION
FUNCTION STUDIES FOR POOR COUNTRIES

Variable, and its Relationship to Student Performance		Statistically Significant with Expected Sign	Non-Statistically Significant, or with Opposite Sign
Variable	Expected Sign		
<u>Background Variables and Schooling Variables</u>			
SES has strong effect at primary and lower secondary grades for all subjects.	+	Epstein Simmons-Askoy S'bein-Farrell Carnoy (R.F.) Beebout IEA science IEA reading	Carnoy-Thias (grade 7) Carnoy (S.F.)
SES has less effect in developing c.f. developed countries		S'bein-Farrell (?) IEA science IEA reading	
SES has diminishing effect throughout secondary cycle		Carnoy-Thias Carnoy Beebout (English) IEA science IEA reading	Beebout (Malay)
Schooling variables have some effect at lower grades, but a stronger effect in upper secondary grades	?	Carnoy-Thias Carnoy IEA science IEA reading	
Schooling variables have some effect on native language beyond primary grades	+	IEA reading	Simmons-Askoy
<u>Individual Schooling Variables</u>			
Per-pupil expenditures on school facilities or teachers	+		Levy Thias-Carnoy (grade 11) Beebout

Variable, and its Relationship to Student Performance	Expected Sign	Statistically Significant with Expected Sign	Non-Statistically Significant, or with Opposite Sign
Variable			
Average class size, or pupil:teacher ratio	-	Carnoy Beebout	Levy Thias-Carnoy (grade 7) S'bein-Farrell IEA science IEA reading
Teacher certification and academic qualification at primary and lower secondary grades	+	Carnoy	Levy Thias-Carnoy (grade 7) S'bein-Farrell
Teacher certification and academic qualification at upper secondary grades	+	Beebout IEA science	Carnoy-Thias Carnoy
Teacher contract (tenure) at upper secondary grades	+	Carnoy	Carnoy-Thias
Teacher experience at primary and lower secondary grades	+	Thias-Carnoy (grade 7) S'bein-Farrell Carnoy	Carnoy-Thias
Teacher experience at upper secondary grades	+	Beebout	Carnoy-Thias Carnoy
Teacher sex - males at primary and lower secondary grades; females at upper secondary grades	+	Carnoy-Thias Beebout IEA science IEA reading	Thias-Carnoy (grade 7) Carnoy
Teacher motivation	+	IEA science	
Textbook availability at primary grades	+	S'bein-Farrell IEA science	
Availability and use of library	+	Beebout IEA reading	
Homework and free reading at home	+	S'bein-Farrell Simmons-Askoy IEA science IEA reading	

Variable, and its Relationship to Student Performance		Statistically Significant with Expected Sign	Non-Statistically Significant, or with Opposite Sign
Variable	Expected Sign		
Boarding at secondary grades	+	Thias-Carnoy (grade 11) Carnoy-Thias	Beebout
Grade repetition	-	Levy Thias-Carnoy (grade 7) Simmons-Askoy	Beebout
Double sessions	-	Beebout	S'bein-Farrell
Size of school enrollment at upper secondary grades	?	(+) Thias-Carnoy (grade 11) IEA science	(-) Beebout
Performance and attitudes of classroom peer-group	+	Carnoy-Thias S'bein-Farrell	

The countries in which these studies were conducted are:

Levy	International
Epstein	St. Lucia
Thias-Carnoy, grades 7 & 11	Kenya
Simmons-Askoy	Tunisia
Carnoy-Thias	Tunisia
Schiefelbein-Farrell	Chile
Carnoy	Puerto Rico
Beebout	Malaysia
IEA science & reading	International

Annex Table 2

DESCRIPTION OF EDUCATIONAL PRODUCTION FUNCTION STUDIES EXPLAINING STUDENT COGNITIVE ACHIEVEMENT IN DEVELOPING COUNTRIES

Author(s) and Publication date	Country	Sample		Statistical Procedure	Measure of Student Academic Achievement
		Primary or Lower Secondary Grade	Upper Secondary Grade		
Thiao-Carney 1969	Kenya	3,405 rural primary students in grade 7 in a random sample of 89 primary schools		O.L.S. multiple regression	Average student score on Kenya Preliminary Examination for each school
Thiao-Carney 1969	Kenya		Students in 115 rural and urban schools in Form IV (grade 11)	O.L.S. log-linear multiple regression	Average student score on Cambridge School Certificate Examination for each school
Carney 1971	Puerto Rico	182,000 students in grades 3, 6, 9 and 12 of all public schools		O.L.S. and two stage least squares multiple regression	Average student score on a Spanish reading examination for each school*
Yendi 1971	Congo		1,450 students in grades 11 and 12 selected randomly from 25 secondary schools	Stepwise O.L.S. multiple regression	Individual scores on IEA** multiple choice tests in French and mathematics
Simmons 1972	Tunisia	44 students from a village and 80 students from an urban suburb, all in grades 4 to 8		Stepwise O.L.S. multiple regression	Individual scores on multiple choice tests in Arabic, French and arithmetic
Seebout 1972			7,674 students in grades 10 and 11 in a random sample of 89 secondary schools	O.L.S. multiple regression using both a quadratic and linear functional form	An index of individual student performance relative to that of his peers; performance defined as the difference between secondary entrance and final examination scores
Camber and Kaaves, Thorndike 1972**	International, viz. Chile, India, Iran, Thailand	258,000 students in 9,700 schools randomly selected in 15 developed countries and 4 developing countries. Three populations were tested -- primary students aged 10, lower secondary students aged 14 and students in the terminal upper secondary year		Stepwise O.L.S. multiple regression	Individual scores on internationally developed multiple choice tests in science and native language reading comprehension***
Schleselman-Parrell 1973	Chile	353 randomly selected 8th grade classes in both primary and secondary schools with an average response of 10 students per class		O.L.S. multiple regression and commonality analysis	Individual scores on national 8th grade test in Spanish and arithmetic
Ryan 1973	Iran	797 2nd grade students selected randomly from 66 rural schools in 2 provinces		O.L.S. multiple regression and commonality analysis	Individual scores on multiple choice tests in Persian and arithmetic
Carney-Thiao 1974	Tunisia	6,195 students in grades 7, 8, 9, 10 and 11 randomly selected from rural and urban secondary schools		Stepwise O.L.S. multiple regression	Individual student grade point average on school examinations.

* Other Endogenous variables in the simultaneous equation model were the student's expected level of schooling, self-esteem, and desire to transfer to another school.

** IEA - International Association for the Evaluation of Education and Achievement.

***Other subjects tested were literature, French as a foreign language, English as a foreign language, and civics.

†(O.L.S.) - Ordinary Least Squares.

APPENDIX

OTHER EXPLANATIONS OF SCHOOLING OUTPUTS

There are at least two other studies which explain schooling outputs by using statistical techniques other than multiple regression. These studies include Holsinger (1973) and Chopra (1967). Holsinger employs analysis of differences of means to show that primary schools in a major Brazilian city do have unique attributes which result in modernization of personality traits among students. This attitude is produced independently of the socio-economic background of the students, and thereby indicates a positive role for policy controlled schooling inputs in less developed countries.

Sample: Eight percent of the primary school population of Brasilia i.e., 2,534 students, whose classrooms were chosen at random and stratified by grade. Also a control group of children of the same age but with no schooling was chosen and matched with the experimental group as closely as possible for socio-economic background.

Variables: Modernity was indicated by the Smith-Inkeles Long Form test, with the response score comprising an average of two points for a modern answer and one point for a traditional answer.

Results: Both cross-sectional analysis (score increments for each grade level) and longitudinal analysis (comparison of results at a given time with those of a follow-up sub sample) showed significant increases in modernity because of both any schooling and increased years of schooling. Control for SES was achieved by comparing low SES student scores from both the schooled group and the non-schooled control group. Again, a significant difference in the mean modernity score was indicated. Control for IQ was achieved by stratifying according to native IQ and then following individual student modernity scores as they progressed through the school system.

In summary, although this study contrasts to others which have cognitive achievement or school retention as an output, it still gives no real help in policy making. We must have, and Holsinger proposes to pursue, further analysis to determine exactly which of the schooling inputs are mainly responsible for increasing modernity in students. However, there is now a prima facie case for including modernity as an output in future studies of LDC schools. If it could further be shown that cognitive achievement and/or earnings were determined by increasing modernity, then these studies would have real economic significance.

Chopra (1967), uses analysis of differences of means to examine the relationship between academic achievement and socio-economic background of students.

Sample: 1,359 students at the secondary level in 22 urban and 6 rural schools of the Lucknow district of India.

Variables:

- | | |
|---------------------------------|--|
| (i) Intelligence | - the Progressive Matrices Test. |
| (ii) Achievement | - a generally entered High School Examination. |
| (iii) Socio-economic Background | - parental occupation, graded into seven subdivisions. |

Results: The study was designed to prevent variation in schooling variables affecting the relationship between SES and achievement. The schools chosen in the sample were only those with a 'minimum' standard of buildings, equipment and staff. However, the choice of an arbitrary minimum does not prevent variations above this level from having an effect. Given this caveat, the study finds significant differences between mean achievement scores for different occupational groups both with and without controls for student intelligence. This again indicates the importance of socio-economic background as represented by the level of parental occupation.

BIBLIOGRAPHY

A. Selected Studies Concerned with Educational Production Functions for the United States

Astin, Alexander W. "Undergraduate Achievement and Institutional Excellence." Science. Vol. 161, August 16, 1968, pp. 661-668.

Averch, Harvey A. et al. How Effective is Schooling? An Initial Review and Synthesis of Research Findings. (Santa Monica, Calif.: Rand Corporation, R-956 - PCSF/RC, March 1972).

Boardman, Anthony E., Otto A. Davis and Peggy R. Sanday. "A Simultaneous Equations Model of the Educational Process." Working Paper, Carnegie Mellon University School of Urban and Public Affairs. September 1973.

Bowles, Samuel. "Towards an Educational Production Function." In W.L. Hansen, ed. Education, Income, and Human Capital. N.B.E.R., Studies in Income and Wealth. Vol. 35, New York, 1970.

Burkhead, Jesse, Thomas G. Fox and John W. Holand. Input and Output in Large City High Schools. (Syracuse: Syracuse University Press, 1967).

Feldman, Kenneth A., and Theodore M. Newcomb. The Impact on College Students. Vol. 1. (San Francisco: Jossey-Bass, 1969).

Hanushek, Eric. "The Production of Education, Teacher Quality, and Efficiency." U.S. Department of Health, Education, and Welfare. Do Teachers Make a Difference?

Keisling, Herbert J. "Multivariate Analysis of Schools and Educational Policy." (Santa Monica, Calif.: Rand Corporation, March 1971).

Levin, Henry M. "A New Model of School Effectiveness." U.S. Department of Health, Education, and Welfare. Do Teachers Make a Difference?

_____. "Concepts of Economic Efficiency and Educational Production." N.B.E.R., Conference on Education as an Industry. June 4-5, 1971a. (A revised version is presented in Levin 1971b.)

_____. "Frontier Functions: An Econometric Approach to the Evaluation of Educational Effectiveness." Stanford Center for Research and Development. Memorandum No. 80, November 1971b.

Mayeske, George W. "Teacher Attributes and School Achievement." U.S. Department of Health, Education and Welfare: Do Teachers Make a Difference?

BIBLIOGRAPHY (Continued)

Thomas, J. Alan. "Efficiency in Education: An Empirical Study." Administrator's Notebook. Vol. 12-2, October 1962.

U.S. Department of Health, Education, and Welfare. Do Teachers Make a Difference? (Washington, D.C.: U.S. Office of Education, 1970).

B. Educational Production Function Studies for Less Developed Countries

Beebout, Harold S. "The Production Surface for Academic Achievement: An Economic Study of Malaysian Secondary Education." Unpublished Ph.D. dissertation. (University of Wisconsin at Madison: Department of Economics, 1972).

Carnoy, Martin, and H. M. Levin. "A Systems Approach to Research for Educational Development in Venezuela." (Stanford University: School of Education, 1970). Unpublished ms.

_____. "Family Background, School Inputs and Students' Performance in School: The Case of Puerto Rico." (Stanford University School of Education, 1971a). Unpublished ms.

_____. "A Systems Approach to Evaluating Education, Illustrated with Puerto Rican Data." (Stanford University: School of Education, 1971b).

_____, and Hans H. Thias. Draft Report of Second Tunisia Education Research Project. I.B.R.D. RPO 248, 1974. Unpublished ms.

Comber, L.C. and John P. Keeves. Science Education in Nineteen Countries. International Association for the Evaluation of Educational Achievement, International Studies in Evaluation I. (New York: Halsted Press, 1973).

Drysdale, Robert. "Factores determinantes de la deservion escolar en Colombia." Revista del Centro de Estudios Educativos. Vol. II, No. 3, Mexico, 1972.

Epstein, Ervin H. "Ecological Factors in Comparative Analysis: Effects on School Achievement in St. Lucia." Comparative Education Review. October 1970, pp. 312-321.

Garcia, Casteneda, de Leon, and Ernesto Schiefelbein. "Televisión y rendimiento escolar." Ministerio de Educacion de Venezuela, Comité de Teleducación, 1973. Unpublished ms.

BIBLIOGRAPHY (Continued)

- Levy, Mildred B. "Determinants of Primary School Drop-outs in Developing Countries." Comparative Education Review. February 1971, pp. 44-58.
- Ryan, John W. "Educational Resources and Scholastic Outcomes: A Study of Rural Primary Schooling in Iran." Unpublished Ph.D. dissertation. (Stanford University: School of Education, 1973).
- Schiefelbein, Ernesto, and Joseph Farrell. "Factors Influencing Academic Performance Among Chilean Primary Students." Paper presented at the Annual Meeting of the International Society of Educational Planners and the American Association for the Advancement of Science. Mexico City, June 1973.
- Simmons, John. Towards an Evaluation of Adult Education in a Developing Country. Vols. I and II. (UNESCO Parts & USAID, Tunis, 1970/72).
- Simmons, John, and Sumru Askoy. "Schooling for Development? Students and Workers in Tunisia." (Harvard University: Department of Economics, 1972). Unpublished ms.
- Thias, Hans Heinrich, and Martin Carnoy. Cost Benefit Analysis in Education: A Case Study on Kenya. Chapter VII. I.B.R.D. Report No. EC-173. November 1969.
- Thorndike, Robert L. Reading Comprehension in Fifteen Countries. International Association for the Evaluation of Educational Achievement, International Studies in Evaluation III. (New York: Halsted Press, 1973).
- Wolff, Laurence. "The Use of Information for Improvement of Educational Planning in Rio Grande do Sul, Brazil." Unpublished Ph.D. dissertation. Harvard University, 1971.
- Youdi, Robert V. "An Exploratory Study of Achievement and Attitudes of High School Students in the Congo: An Aspect of Socialization for National Development." Unpublished Ph.D. dissertation. (Stanford University: School of Education, 1971).
- C. Studies Explaining Cognitive Achievement in Less Developed Countries Using Statistical Techniques Other Than Multiple Regression
- Chopra, S.L. "Parental Occupation and Academic Achievement of High School Students in India." The Journal of Educational Research. April 1967, pp. 359-362.

BIBLIOGRAPHY (Continued)

Farquhar, W.M., and E.W. Christensen. Motivational Factors Influencing Academic Achievement of Eleventh Grade Puerto Rican High School Students. (Lansing, Michigan: Michigan State University Press, 1968).

Holsinger, Donald B. "The Elementary School as Modernizer: A Brazilian Study." Paper presented at 67th Annual Meeting of American Sociological Association. February 1973.

Weightman, George H., and Zahi Rihani. "Social Stratification and Adolescent Achievement in a Lebanese Town." Comparative Education Review. June 1967, pp. 208-216.

D. Other Related Studies for Developed Countries

Brown, G.E., and L.B. Brown. "Research Note on the Educational Achievement of Dutch and Greek Children in Wellington." New Zealand Journal of Educational Studies. November 1970, pp. 163-166.

Marklund, Sixten. "School Organization, School Location, and Student Achievement." International Review of Education. 1969, No. 3, pp. 295-320.

Orta, Gina R. "Educational Achievement of Primary School Graduates in Israel Related to their Socio-Cultural Background." Comparative Education. November 1967.

Simmons, John. "Education, Poverty and Development." (Washington, D.C.: I.B.R.D., Working Paper, 1974).